

UNCLASSIFIED

AD NUMBER	
AD373294	
CLASSIFICATION CHANGES	
TO:	unclassified
FROM:	confidential
LIMITATION CHANGES	
TO:	Approved for public release, distribution unlimited
FROM:	Distribution: Further dissemination only as directed by Office of Naval Research, Attn: Code 418, One Liberty Center, 875 North Randolph Street, Arlington, VA 22203-1995, JAN 1966, or higher DoD authority.
AUTHORITY	
ONR ltr dtd 30 Aug 2010; ONR ltr dtd 30 Aug 2010	

THIS PAGE IS UNCLASSIFIED

UNCLASSIFIED

AD NUMBER
AD373294
CLASSIFICATION CHANGES
TO
confidential
FROM
secret
AUTHORITY
30 apr 1978, DoDD 5200.10 gp-3

THIS PAGE IS UNCLASSIFIED

AD- 373294

SECURITY REMARKING REQUIREMENTS

DOD 5200.1-R, DEC 78

REVIEW ON 23 APR 86

SECURITY

MARKING

The classified or limited status of this report applies to each page, unless otherwise marked.

Separate page printouts MUST be marked accordingly.

THIS DOCUMENT CONTAINS INFORMATION AFFECTING THE NATIONAL DEFENSE OF THE UNITED STATES WITHIN THE MEANING OF THE ESPIONAGE LAWS, TITLE 18, U.S.C., SECTIONS 793 AND 794. THE TRANSMISSION OR THE REVELATION OF ITS CONTENTS IN ANY MANNER TO AN UNAUTHORIZED PERSON IS PROHIBITED BY LAW.

NOTICE: When government or other drawings, specifications or other data are used for any purpose other than in connection with a definitely related government procurement operation, the U. S. Government thereby incurs no responsibility, nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.

373294

PUBLISHED BY THE ELECTRO-PHYSICS LABORATORIES

INTERNAL TECHNICAL MEMORANDA (ITM)

Contain results or data of a preliminary nature and do not necessarily reflect the final opinion of the Electro-Physics Laboratories; specifically intended for internal guidance and documentation only. (Red Cover)

EXTERNAL TECHNICAL MEMORANDA (ETM)

Technical reports of experimental and/or theoretical investigations normally issued to provide documentation for general use either within or external to the Laboratories. (Yellow Cover)

ITT ELECTRO-PHYSICS LABORATORIES, INC.

DDC CONTROL
NO 62790

SECRET

This document consists of 64
pages. No. 2 of 105, Series A

AN ANALYSIS OF LINE-OF-SIGHT HF RADAR
OBSERVATIONS FOR THE SA-5 AND SA-6 LAUNCHES
AND SOME COMPARISONS WITH VHF TELEMETRY
MEASUREMENTS

(TITLE: SECRET)

RADAR AND TELEMETRY OBSERVATIONS
FOR TWO SATURN LAUNCH VEHICLES

(TITLE: UNCLASSIFIED)

This report is the SIXTY-FIFTH of a series of CHAPEL BELL reports (formerly TEPEE reports) made under Contract Nonr-4204(00) under the joint sponsorship of the Office of Naval Research and the Advanced Research Projects Agency (ARPA Order 32)

DDC AVAILABILITY NOTICE

All distribution of this report is controlled. Qualified DDC users shall request with certification of "need-to-know" from the cognizant military agency of their project or contract through:

OFFICE OF NAVAL RESEARCH
DEPARTMENT OF THE NAVY
WASHINGTON, D. C. 20360
Attn: Code 418

This document may be reproduced to satisfy official needs of U. S. Government agencies. No other reproduction authorized except with permission of:

OFFICE OF NAVAL RESEARCH
DEPARTMENT OF THE NAVY
WASHINGTON, D. C. 20360
Attn: Code 418

DDC CONTROL
NO62790

Group 3

Downgraded at 12-year intervals
not automatically declassified.

SECRET

SECRET

AN ANALYSIS OF LINE-OF-SIGHT HF RADAR
OBSERVATIONS FOR THE SA-5 AND SA-6 LAUNCHES
AND SOME COMPARISONS WITH VHF TELEMETRY
MEASUREMENTS

(TITLE: SECRET)

RADAR AND TELEMETRY OBSERVATIONS
FOR TWO SATURN LAUNCH VEHICLES

(TITLE: UNCLASSIFIED)

Prepared by:

C. A. Bowser
C. A. Bowser
Physicist

H. F. Busch
H. F. Busch
Manager, Special Projects

Approved by:

J. M. Kelso
J. M. Kelso
Director of Research

Date: April 1966

Wm. T. Whelan
Wm. T. Whelan
Director, Electro-Physics Laboratories

SECRET

SECRET

TABLE OF CONTENTS

Section	Page
1. <u>INTRODUCTION</u>	1-1
2. <u>DATA AND DISCUSSION</u>	2-1
2.1. THE SA-5 FLIGHT	2-1
2.1.1. <u>VHF Telemetry from the SA-5 Vehicle</u>	2-1
2.1.2. <u>Signatures Observed with HF Polystatic Direct-Look Radars</u>	2-4
2.1.2.1. Cape Kennedy Receiving Brunswick	2-4
2.1.2.2. San Salvador Receiving Brunswick	2-8
2.1.2.3. Brunswick Receiving San Salvador	2-14
2.1.2.4. Cape Kennedy Receiving San Salvador	2-20
2.1.2.5. Brunswick Monostatic	2-24
2.2. THE SA-6 FLIGHT	2-24
2.2.1. <u>VHF Telemetry from the SA-6 Vehicle</u>	2-24
2.2.2. <u>Signatures Observed with HF Polystatic Direct-Look Radars</u>	2-27
3. <u>FLAME-ASSOCIATED VHF AND HF PHENOMENA</u>	3-1
4. <u>CONCLUSIONS</u>	4-1
5. <u>REFERENCES</u>	5-1

SECRET

SECRET

LIST OF FIGURES

Figure		Page
1	Line-of-sight radar locations with respect to SATURN launch azimuth.	1-3
2	SATURN block 2 vehicle, telemetry antenna and retro-rocket locations.	2-2
3	Telemetry signal attenuation due to SA-5 retro-rockets.	2-3
4	AMR test 0169, SATURN SA-5, Cape Kennedy receiving Brunswick, Georgia, operating frequency - 22.7 Mc/s.	2-5
5	Signature cross section, SATURN SA-5, Cape Kennedy receiving Brunswick, Georgia.	2-7
6	Comparison of retro-rocket plume size and VHF telemetry signal strength, SATURN SA-5 vehicle.	2-9
7	Measured VHF telemetry signal strengths, Grand Bahama Island, link. (After Ely, et al., p. 43 of Ref. 4.)	2-10
8	Measured SHF signal strengths, C-band radar, San Salvador. (After Ely, et al., p. 53 of Ref. 4.)	2-11
9	AMR test 0169, SATURN SA-5, San Salvador receiving Brunswick, Georgia, operating frequency - 22.7 Mc/s.	2-12
10	Signature cross section, SATURN SA-5, San Salvador receiving Brunswick, Georgia.	2-13
11	AMR test 0169, SATURN SA-5, Brunswick, Georgia receiving San Salvador, operating frequency - 22.8 Mc/s.	2-15
12	Signature cross section, SATURN SA-5, Brunswick, Georgia receiving San Salvador.	2-16
13	AMR test 0169, SATURN SA-5, Brunswick, Georgia receiving San Salvador, operating frequency - 22.8 Mc/s.	2-18
14	Comparison of calculated and observed doppler-spectrum lines, SATURN SA-5 stages S-I and S-IV, Brunswick, Georgia receiving San Salvador.	2-19

SECRET

SECRET

LIST OF FIGURES (continued)

Figure		Page
15	AMR test 0169, SATURN SA-5, Cape Kennedy receiving San Salvador, operating frequency - 22.8 Mc/s.	2-21
16	AMR test 0169, SATURN SA-5, Cape Kennedy receiving San Salvador, operating frequency - 22.8 Mc/s.	2-22
17	Comparison of calculated and observed doppler-spectrum lines, SATURN SA-5, stages S-I and S-IV, Cape Kennedy receiving San Salvador.	2-23
18	AMR test 0169, SATURN SA-5 signature, liftoff - 1625:01Z, Brunswick, Georgia monostatic radar, 29 January 1964.	2-25
19	Cross section of the Brunswick, Georgia monostatic retro-rocket signature, SATURN SA-5.	2-26
20	Telemetry signal attenuation due to retro-rockets.	2-28
21	AMR test 2769, SATURN SA-6, Cape Kennedy receiving San Salvador, operating frequency - 17.7 Mc/s.	2-29
22	AMR test 2769, SATURN SA-6, MTI record, Cape Kennedy receiving San Salvador, operating frequency - 17.7 Mc/s.	2-31
23	AMR test 2769, SATURN SA-6, doppler spectrum, Cape Kennedy receiving San Salvador, operating frequency - 17.7 Mc/s.	2-32
24	AMR test 2769, SATURN SA-6, doppler spectrum (continued), Cape Kennedy receiving San Salvador.	2-34
25	Comparison of calculated and observed doppler spectrum, SATURN SA-6, stages S-I and S-IV, Cape Kennedy receiving San Salvador.	2-35

SECRET

SECRET

ABSTRACT

The records obtained in line-of-sight, HF radar observations during two SATURN rocket launches (SA-5 and SA-6) are analyzed. The measurements were made as a part of a close-in phenomenology program which covered approximately 60 launches of various types of vehicles from the Air Force Eastern Test Range (AFETR). Results pertaining to other types of vehicles are reported separately.

The line-of-sight observations employed HF pulse transmitters at Brunswick, Georgia and San Salvador Island. Each site received its own transmission monostatically, and the other site's transmissions bistatically. Both transmissions were received bistatically at Cape Kennedy, Florida.

The pulse amplitude data have been analyzed to obtain the radar cross sections, which are presented as functions of time. The variation of these cross sections with additional parameters, such as altitude, aspect angle, and bistatic angle, are discussed. The results are also compared with information recently released concerning rocket-exhaust effects upon VHF telemetry transmissions during the two launches of interest. A time-correlation of VHF attenuation events with increases in HF radar cross section is noted, especially at first-stage retro-rocket ignition.

Selected portions of the HF radar data have been analyzed as pulse-doppler data to obtain the doppler spectra. When the vehicle is above 100 kilometers (km) in altitude, the doppler spectrum suffers substantial spreading, which in some cases completely filled the 50-c/s folded spectrum of the pulse-doppler radars. Similarly, the VHF telemetry signals exhibited spectral spreading, up to a maximum of 1000 c/s.

SECRET

SECRET

1. INTRODUCTION

A series of 'close-in' missile-launch-phenomenology experiments at the Air Force Eastern Test Range (AFETR) were conducted by various organizations under sponsorship of the Advanced Research Projects Agency (ARPA) and the Office of Naval Research (ONR) during early 1964. As part of this program, the Electro-Physics Laboratories (EPL) operated direct-look (line-of-sight) HF radars against most missile and space vehicle launches.

Among the launches probed by HF radars were AFETR test 0169 and test 2769, the SATURN SA-5 and SA-6 vehicles, respectively. Launch-phase signatures were obtained at HF with a variety of monostatic and bistatic radar-path geometries. Figure 1 shows the geographic layout of the close-in sites used for the POLYSTATIC radar operations, and Table 1 shows the radar configurations and antennas used for the SA-5 and SA-6 tests.

Three transmitters were used during the POLYSTATIC experiments: (1) a 300-kw peak-power transmitter located "over-the-horizon" at Muirkirk, Maryland; (2) a 5-kw peak-power transmitter at Brunswick, Georgia; and (3) a 5-kw peak-power transmitter at San Salvador Island. The Brunswick and San Salvador transmitters operated at 100 pulses/second with a 400-microsecond pulse width, while the Muirkirk transmitter operated at 20 pulses/second with a 1-millisecond pulse width. A complete review of the line-of-sight radar systems may be found in Ref. 1, and the primary goals of the POLYSTATIC experiments are detailed in Ref. 2.

Stated briefly, the goal of the POLYSTATIC program was an experimental exposition of the size and nature of the HF radar target evoked during the powered phase of a variety of liquid-propelled and solid-propelled rockets. The ultimate purpose of such an exposition is, of course, to furnish the detailed knowledge of the target properties

SECRET

SECRET

required by a system designer attempting to optimize the design of an OHD radar system.

The nature and properties of the HF radar target are complicated functions of a number of basic parameters, including: time after liftoff; altitude and ambient atmospheric conditions; radar frequency; aspect angle, and (where applicable) bistatic angles; rocket-burn program; rocket type; etc. The range of variability of the parameters may be reduced (as in the present case) by treating, as a group, the tests made for a particular type of vehicle. The effects of the remaining parameters are more difficult to isolate; the effort to do so forms a major part of the analysis, as discussed in the following pages.

An unusual feature of the tests discussed in this report is the availability of supporting data taken in the VHF portion of the spectrum. Recently, Ely and Hockenberger (Refs. 3, 4 and 5) have presented data on the SA-5 and SA-6 flights concerning the effects of rocket exhaust on VHF telemetry and SHF radar performance, which may be directly correlated with some of the signature features observed at HF.

SECRET

SECRET

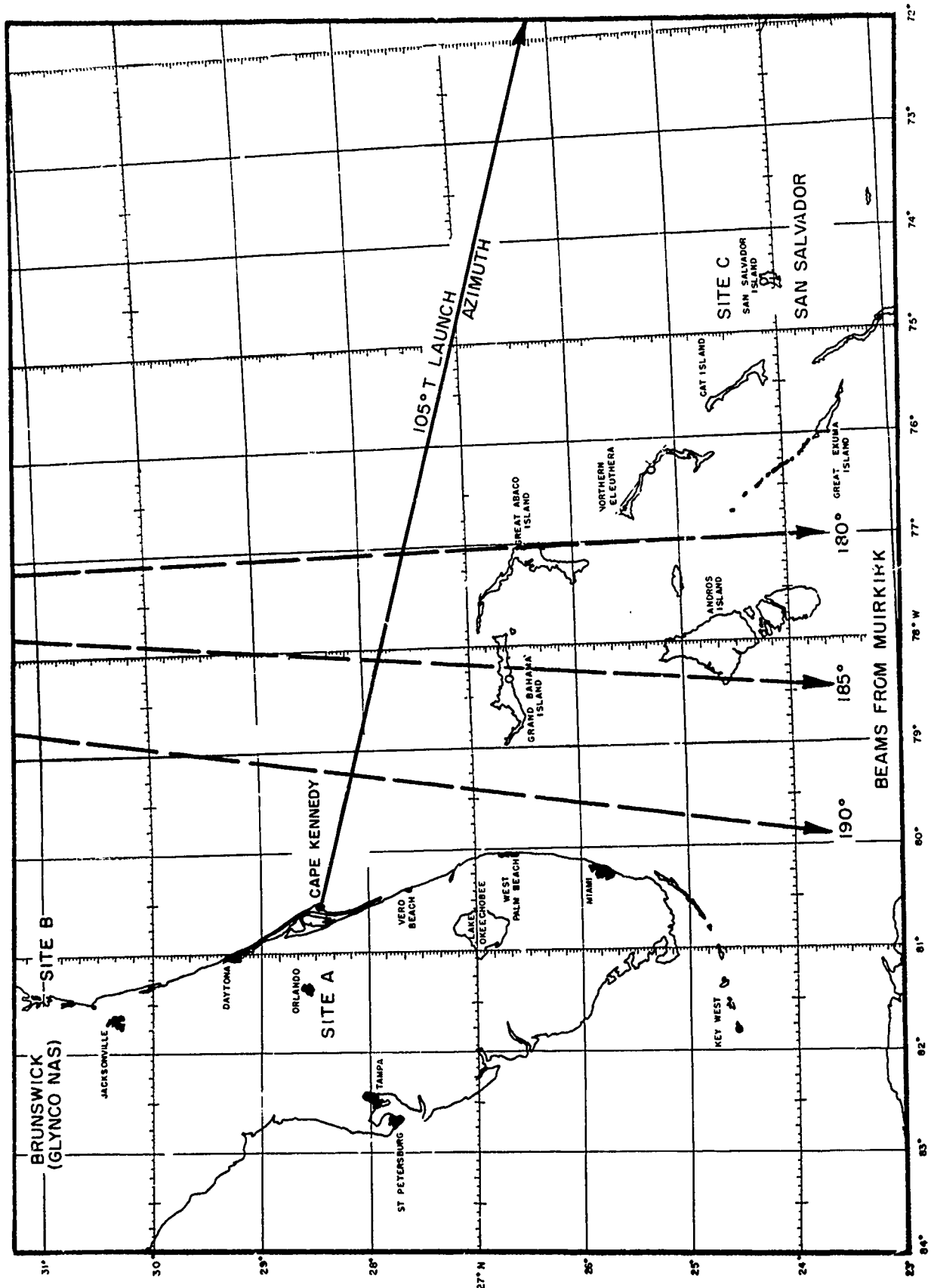


Figure 1. Line-of-sight radar locations with respect to SATURN launch azimuth.

SECRET

SECRET

Table 1. Summary of the radar configurations and antennas used for the SA-5 and SA-6 tests.

Radar Configuration	Test 0169		Test 2769	
	Transmit Antenna	Receive Antenna	Transmit Antenna	Receive Antenna
Cape Kennedy receiving San Salvador	4-element broadside array*	16-element broadside array*	4-element broadside array*	16-element broadside array*
Cape Kennedy receiving Brunswick	4-element broadside array*	16-element broadside array*	4-element broadside array*	16-element broadside array*
Cape Kennedy receiving Muirkirk	Rhombic antenna	log periodic array	log periodic array	log periodic array
	Rhombic antenna	16-element broadside array*	log periodic array	16-element broadside array*
Brunswick receiving Muirkirk	Rhombic antenna	log periodic array	log periodic array	log periodic array
Brunswick receiving San Salvador	4-element broadside array*	4-element broadside array*	4-element broadside array*	4-element broadside array*
Brunswick receiving Brunswick	4-element broadside array*	4-element broadside array*	4-element broadside array*	4-element broadside array*
San Salvador receiving Brunswick	4-element broadside array*	4-element broadside array*	4-element broadside array*	4-element broadside array*
San Salvador receiving San Salvador	4-element broadside array*	4-element broadside array*	4-element broadside array*	4-element broadside array*

*The individual elements consisted of broadband, vertical monopoles.

SECRET

SECRET

These signature features of the SATURN tests show a complex target associated with the S-I and S-IV stages after separation. A discussion of these features and their origin is presented in this report.

Figures 2, 3, 6 and 20 of this report have been reproduced with the permission of the American Institute of Aeronautics and Astronautics (AIAA). These figures originally appeared in the paper "Rocket Exhaust Effects on Radio Frequency Transmission" (Ref. 3 of this report) given by Olen P. Ely and Robert W. Hockenberger at the AIAA 6th Solid Propellant Rocket Conference in Washington, D. C., February 1-3, 1965.

Figures 7 and 8 are after Olen P. Ely, Robert W. Hockenberger, Parley Howell and Geddes Boone. The original figures, from which Figures 7 and 8 were derived, were presented in NASA Technical Memorandum X-53073 (Ref. 4 of this report).

SECRET

SECRET

2. DATA AND DISCUSSION

2.1. THE SA-5 FLIGHT

The SA-5 SATURN test vehicle was launched from Cape Kennedy on 29 January 1964 on a true azimuth of 105° T, at 1625:01 GMT. The test placed an instrument unit (IU) into a 500-day elliptical orbit. Complete staging and performance monitoring measurements were conducted for the test vehicle by the AFETR range instrumentation and tracking facilities.

2.1.1. VHF Telemetry from the SA-5 Vehicle

The measured signal strength of VHF (225 to 260 Mc/s) telemetry transmissions from the SA-5 vehicle indicated a large decrease in signal strength upon ignition of the first (S-I) stage retro-rockets, as compared to pre-retro-ignition signal levels. Location of the retro-rockets with respect to the telemetry antennas is shown in Figure 2.

The retro-thrusters of the SATURN vehicles are small, solid-fueled Aerojet General Genie rockets, while the S-I main propulsion stage and the S-IV second stage are liquid-fueled. Ely and Hockenberger (Ref. 3) report severe attenuation of telemetry signals (observed at Cape Kennedy during the SA-5 tests), ranging from 50 to 60 db for approximately 3 seconds, as shown in Figure 3. The retro-rockets burned for approximately 2 seconds and were ignited at $T_0 + 147.16$ seconds. The onset of absorption was very rapid, taking approximately 0.1 second after retro-ignition for the signal to be attenuated by 60 db on the IU transmissions. Recovery of telemetry signal strength after the termination of retro-rocket burning took approximately 1 second. This extremely high absorption was indicative of a highly ionized region in the vicinity of the missile.

SECRET

SECRET

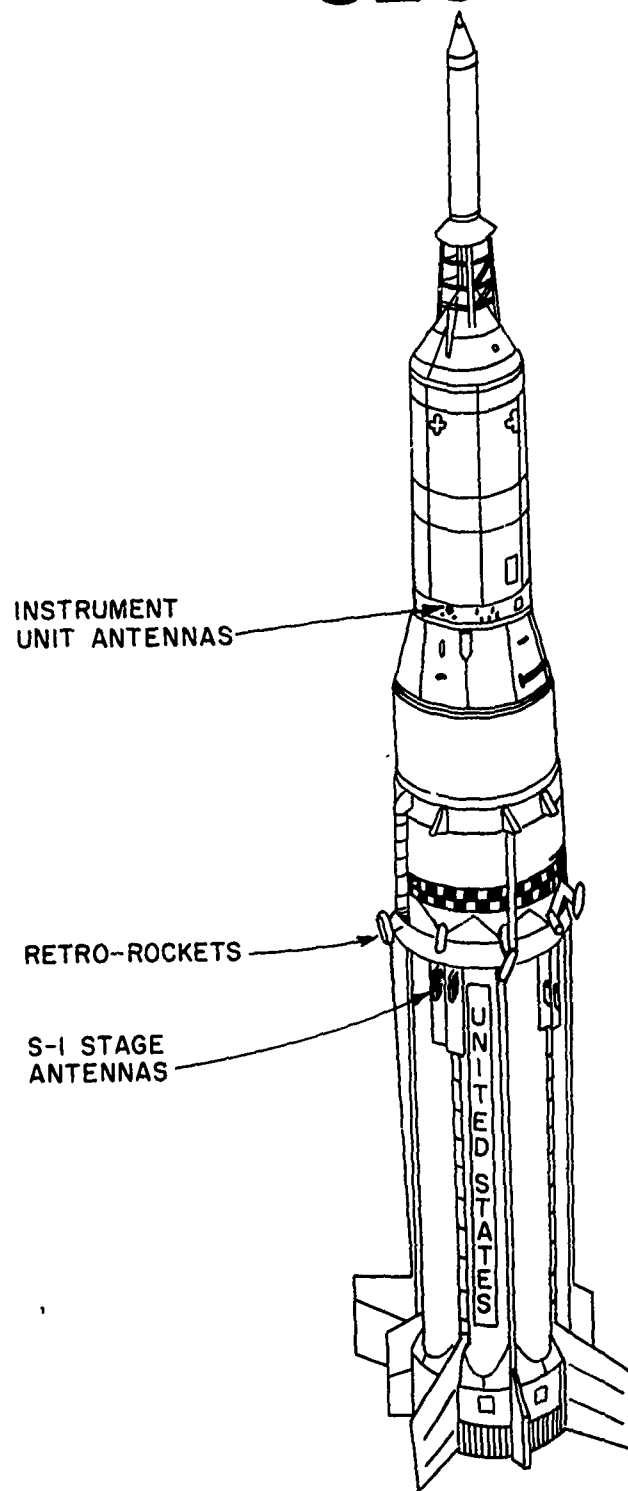


Figure 2. SATURN block 2 vehicle, telemetry antenna and retro-rocket locations.

2-2

SECRET

SECRET

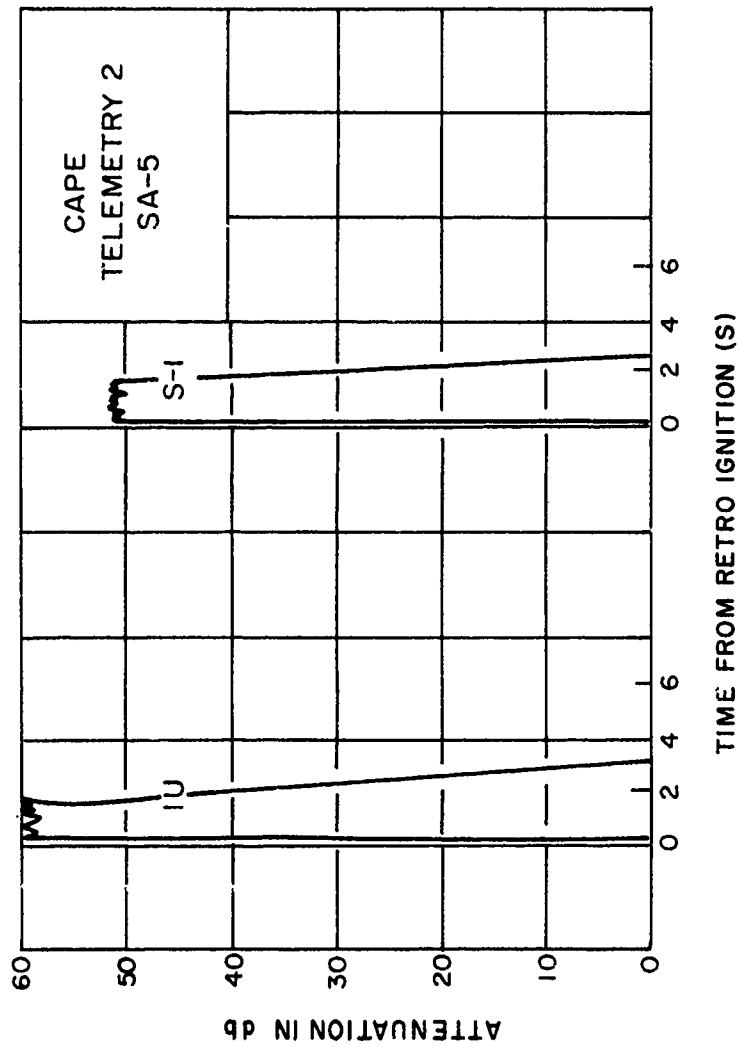


Figure 3. Telemetry signal attenuation due to SA-5 retro-rockets.

SECRET

SECRET

Although some telemetry flame attenuation was observed during both the S-I and S-IV stage propulsion intervals on the Cape telemetry records, these active stages did not produce a total loss of telemetry data. The maximum flame attenuation for the S-I stage was reported as 26 db (Ref. 4, p. 19), while the S-IV stage flame attenuation was considered to have negligible effect on VHF telemetry (Ref. 4, p. 22). The retro-rockets, on the other hand, not only caused a total loss of VHF telemetry at the Cape receiver for several seconds, but also produced a momentary drop of these signals to the receiver threshold at all monitoring sites.

2.1.2. Signatures Observed with HF Polystatic Direct-Look Radars

2.1.2.1. Cape Kennedy Receiving Brunswick

The creation of a local, highly-ionized region by the retro-rockets was verified by the HF radar records to be discussed.

As may be seen in Figure 4, Cape Kennedy's reception of the Brunswick pulse transmissions first displays a missile flame signature from the SA-5 vehicle at $T_0 + 135$ seconds (the missile altitude was approximately 61 km). This signature fades as the S-I stage engines are cut off in the following sequence: inboard engines at $T_0 + 140.75$ seconds, then outboard engines at $T_0 + 146.7$ seconds.

After the ullage rockets and retro-rockets are ignited at $T_0 + 147.2$ seconds, returns are again obtained from the SA-5 rocket at approximately $T_0 + 147.6$ seconds; the amplitude of these echoes becomes very large by $T_0 + 148$ seconds. This specular signature appears for 9 seconds, and its amplitude exhibits the typically high fading rate observed for other missile flame signatures. The HF target is observed approximately 6 seconds longer than the period of high absorption for the VHF telemetry signals from the SA-5 vehicle.

SECRET

SECRET

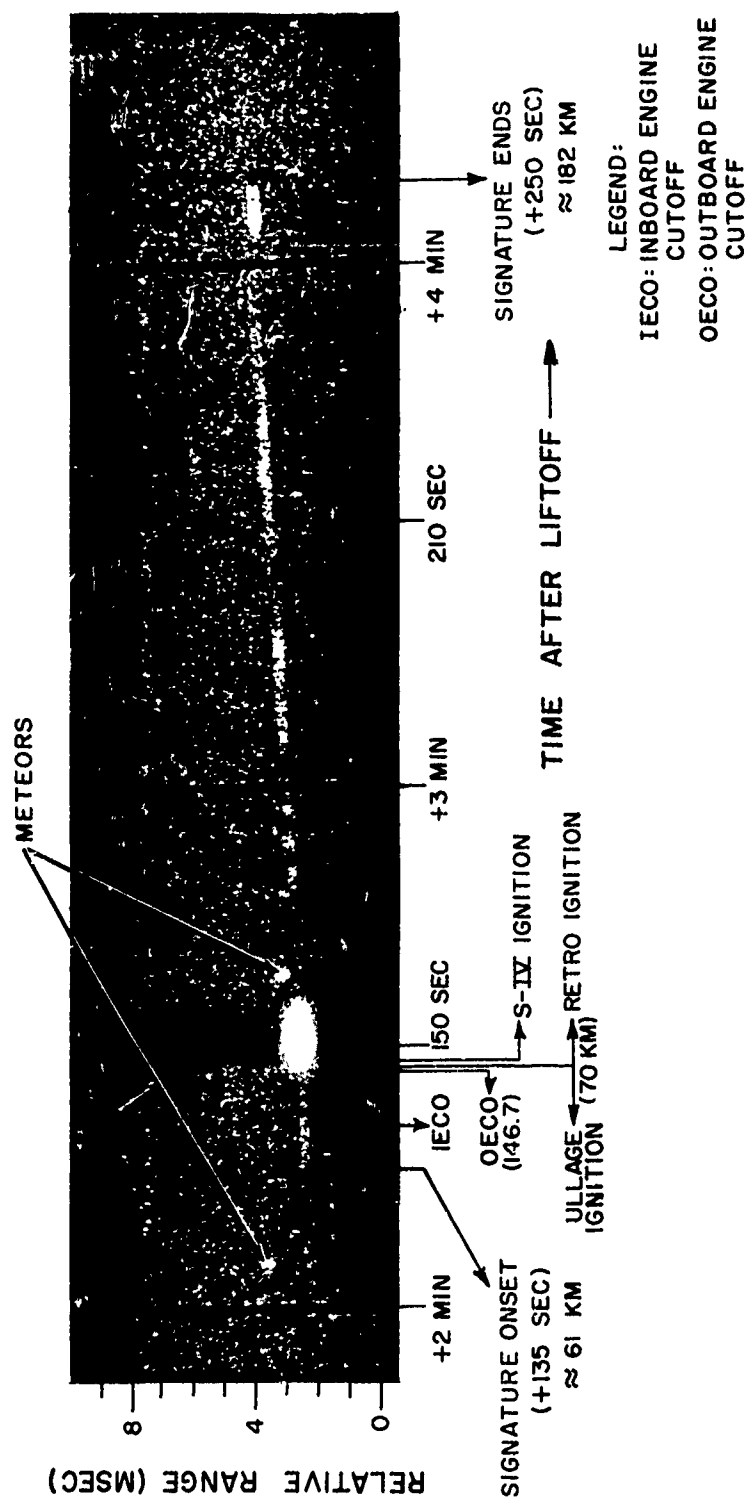


Figure 4. AMR test 0169, SATURN SA-5, Cape Kennedy receiving Frunswick, Georgia, operating frequency - 22.7 Mc/s.

SECRET

SECRET

At $T_0 + 155$ seconds, the amplitude of returns decreases to the noise level, and the flame signature does not reappear until $T_0 + 167$ seconds when the missile reaches an altitude of 100 km.

The flame signature is observed intermittently from $T_0 + 167$ seconds to $T_0 + 250$ seconds, and a very noticeable increase in signal amplitude is observed at $T_0 + 244$ seconds, just before the signature ends. An inspection of the optical tracking records made of the SA-5 flight indicated that a large amount of fuel and/or oxidizer continued to be ejected from the separated S-I stage in the vicinity of the S-IV stage for at least 10 to 20 seconds after retro-rocket ignition. Since the flame from the powered S-I stage before separation produced a clearly distinguishable signature, of modest cross section, ionization from out-gassing after separation could have enhanced the retro-rocket signature and might also have accounted for the longer duration of the HF signature as compared to the duration of the VHF absorption.

The radar cross sections were calculated by the method described in Ref. 6, using the postflight trajectory data and the scalings of the received signal amplitude. The target-echo power produced by the retro-fire event was approximately 3 orders of magnitude larger than that observed for the burning S-I main stage (Figure 5). Since the S-IV stage does not ignite for nearly 3 seconds after the retro-rockets are started, the formation of this highly ionized region should be attributed to a combination effect of the S-I outgassing/afterburning and the retro-rocket flame, with a negligible contribution from the S-IV stage. The large difference in observed target size between the burning solid and liquid stages might be caused by the higher specific impulse delivered to the ambient ionosphere by the forward-directed retro-rockets.

SECRET

SECRET

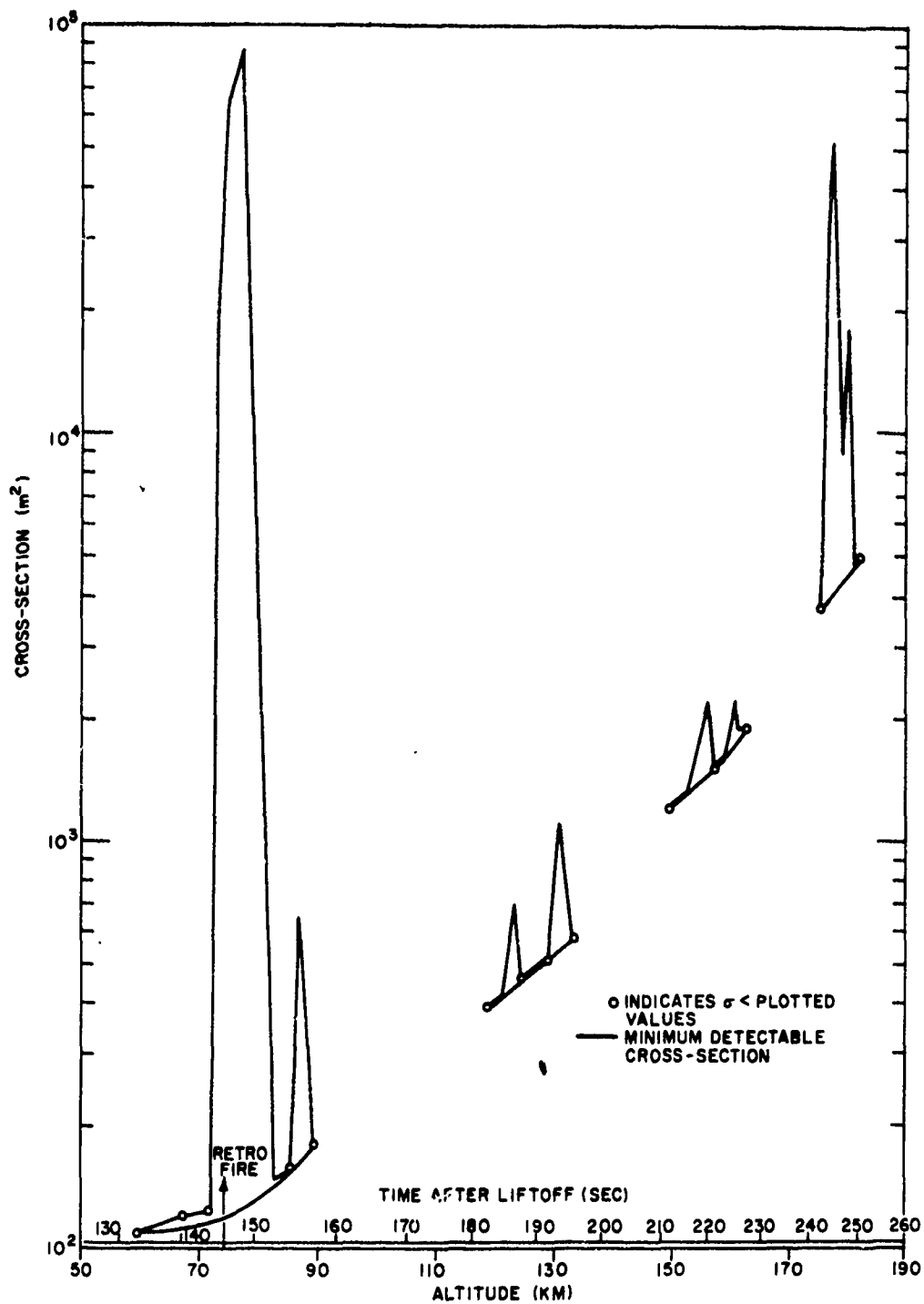


Figure 5. Signature cross section, SATURN SA-5, Cape Kennedy receiving Brunswick, Georgia.

2-7

SECRET

SECRET

From the optical tracking data and characteristics of the tracking telescope, Ely and Hockenberger (Ref. 3) have obtained the approximate time-variation of the optical target diameter, as shown in Figure 6. The relative amplitude of the received telemetry signals and the size of the retro-rocket plume appear to be directly correlated (see Figure 6).

Increased VHF absorption, during another period corresponding to an enhancement of HF signature amplitude, is illustrated further by Figures 4, 5, 7, 8, and 10. The enhanced HF signature at $T_0 + 244$ seconds shown on Figures 4, 5, and 10, occurs at a time of increased absorption (6 to 10 db as seen in Figures 7 and 8) of the VHF telemetry and SHF radar signals observed at Grand Bahama and San Salvador Islands.

2.1.2.2. San Salvador Receiving Brunswick

Figure 9 presents the missile signature obtained from San Salvador reception of the Brunswick transmissions. Before the signature interval, there were moderately strong signals (presumably caused by E_s coupling) at 3 to 4 milliseconds relative range, which tend to mask the onset of the missile signature. The missile signature is recognizable, however, as a drastic increase to the amplitude of radar returns, with some additional echo-pulse spreading. The signature is similar to that obtained from the Cape Kennedy-receiving-Brunswick path except for the much stronger returns appearing in the $T_0 + 2.5$ -minute to $T_0 + 4$ -minute interval, as shown on the San Salvador record.

Retro-rocket ignition again causes a very large increase in echo strength, followed by an interval of weaker returns from the powered S-IV stage, until $T_0 + 164$ seconds when the signature amplitude is again observed to increase. The radar cross section time history of this signature is presented in Figure 10. The cross section was

SECRET

SECRET

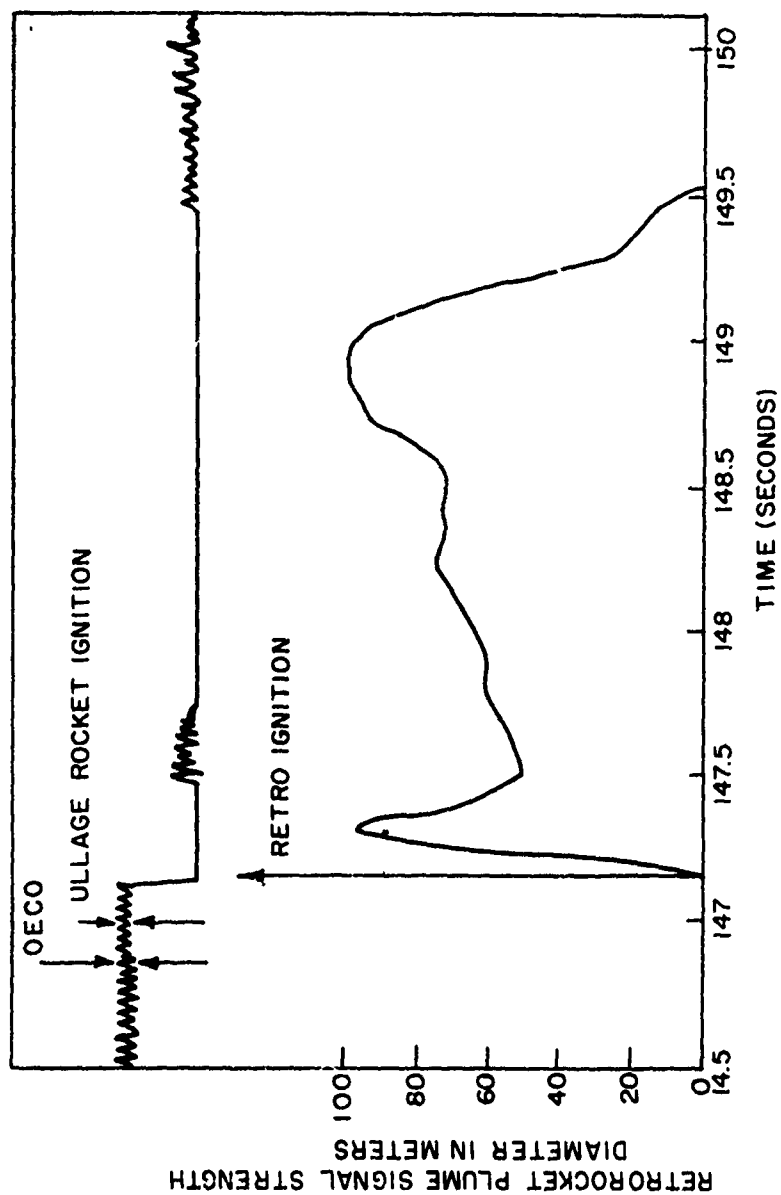


Figure 6. Comparison of retro-rocket plume size and VHF telemetry signal strength, SATURN SA-5 vehicle.

SECRET

SECRET

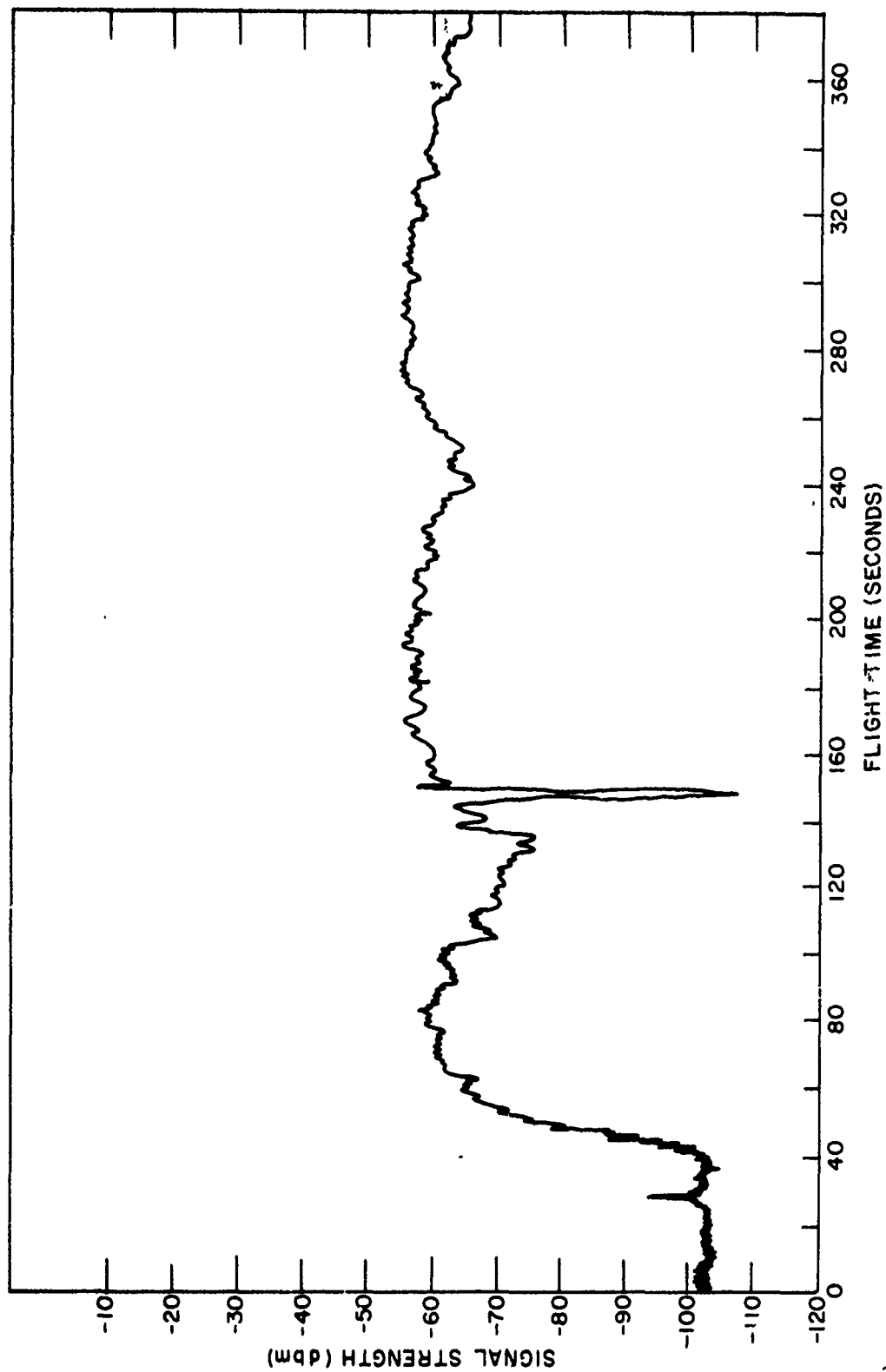


Figure 7. Measured VHF telemetry signal strengths, Grand Bahama Island, link.
(After Ely, et al., p. 43 of Ref. 4.)

2-10

SECRET

SECRET

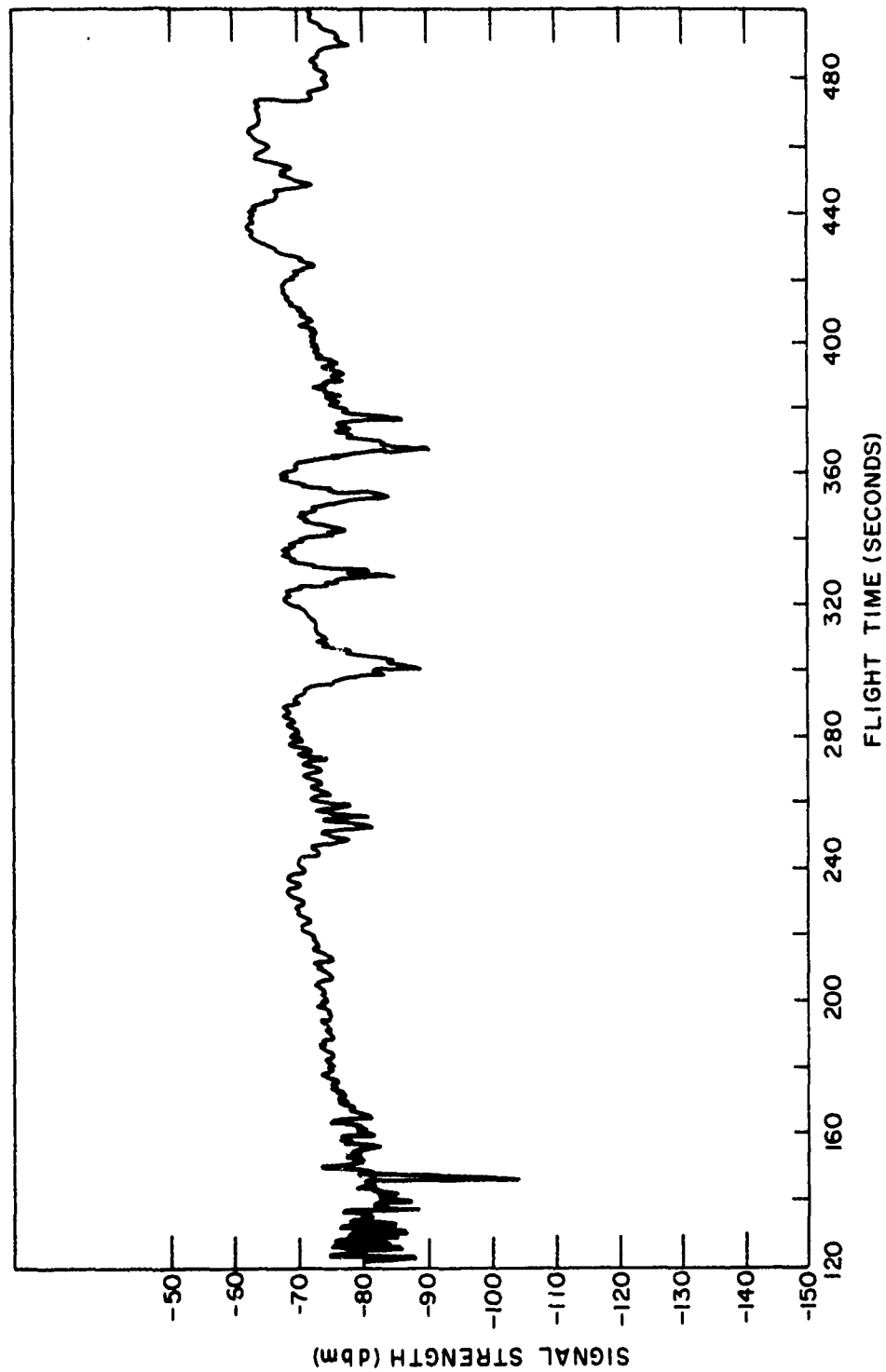


Figure 8. Measured SHF signal strengths, C-band radar, San Salvador.
(After Ely, et al., p. 53 of Ref. 4.)

2-11

SECRET

SECRET

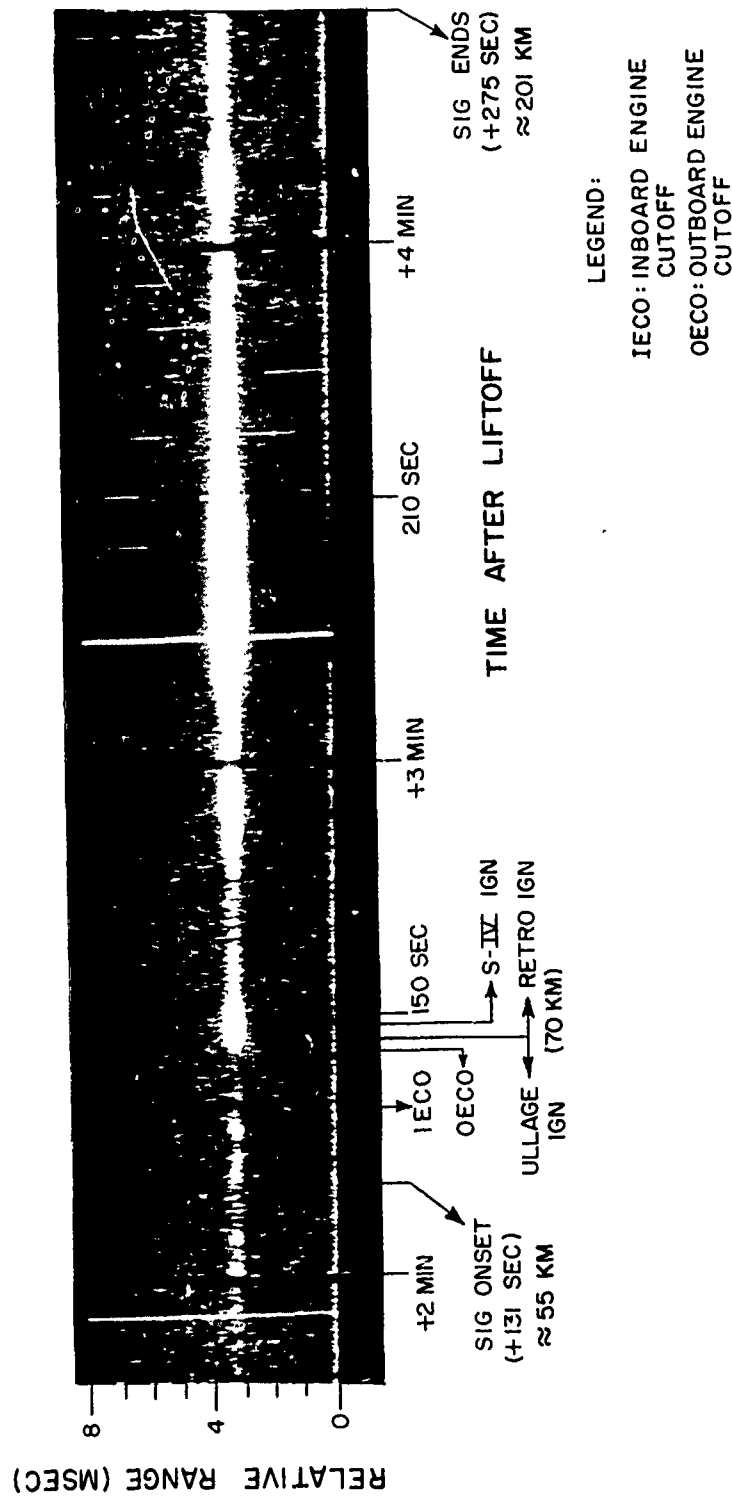


Figure 9. AMR test 0169, SATURN SA-5, San Salvador receiving Brunswick, Georgia, operating frequency - 22.7 Mc/s.

SECRET

SECRET

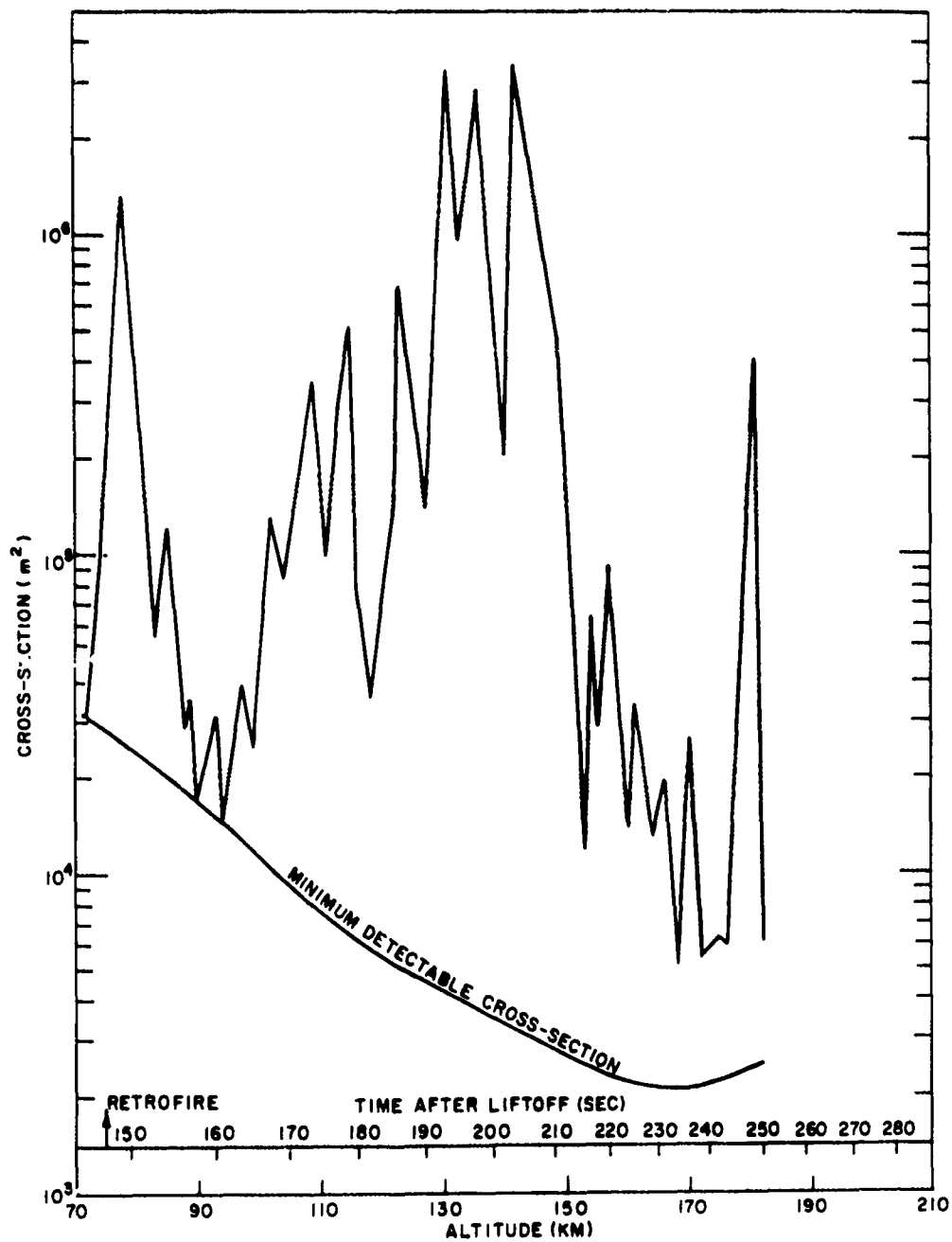


Figure 10. Signature cross section, SATURN SA-5,
San Salvador receiving Brunswick, Georgia.

2-13

SECRET

SECRET

1.3×10^6 square meters immediately after ignition of the retro-rockets ($T_0 + 149$ seconds), and then the cross section dropped to the level of the pre-event E_s -coupling (the minimum detectable cross section at this relative range) 10 seconds later. The target cross section begins to increase as the S-IV stage attains an altitude greater than 100 km; the cross section reaches its maximum value of about 3×10^6 square meters at $T_0 + 205$ seconds.

The target amplitude shows a significant increase in size at approximately $T_0 + 246$ seconds, similar to that observed on the Cape Kennedy-receiving-Brunswick path. San Salvador's reception at Brunswick transmissions exhibits a target size more than an order of magnitude larger than that observed on the Cape Kennedy-receiving-Brunswick path. This effect could possibly result because a substantial part of the Cape Kennedy-receiving-Brunswick transmission path passes through a region of flame attenuation behind the missile.

2.1.2.3. Brunswick Receiving San Salvador

Brunswick's reception of San Salvador transmissions produced the signature shown in Figure 11. This record is similar to the San Salvador-receiving-Brunswick record of Figure 5, showing essentially the same amplitude-time history for the missile signature. The radar cross section time history of this signature is given in Figure 12. The general magnitude of this cross section is equivalent to that of Figure 10 although there are second-to-second differences in the signature fading behavior. The increased size of the radar target created by activation of the retro-rockets, as compared to the earlier S-I stage flame target, is difficult to determine with precision for the records of Figures 9 and 11 because of the intensity of direct-coupling signals.

The radar receiver used for recording San Salvador transmissions at Brunswick was coherent, and, thus, this receiver could provide pulse-doppler information for the signatures obtained. The doppler-frequency

SECRET

SECRET

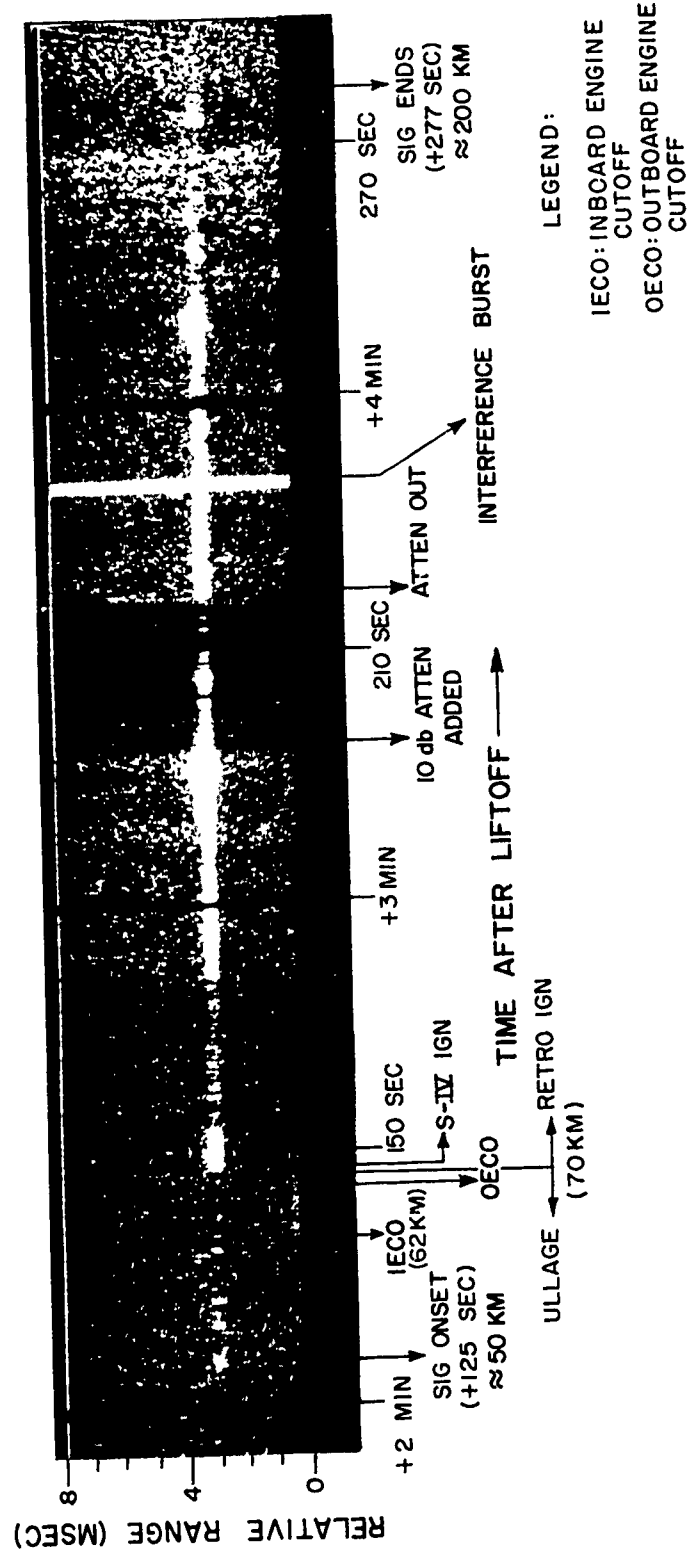


Figure 11. AMR test 0169, SATURN SA-5, Brunswick, Georgia receiving San Salvador, operating frequency - 22.8 Mc/s.

SECRET

SECRET

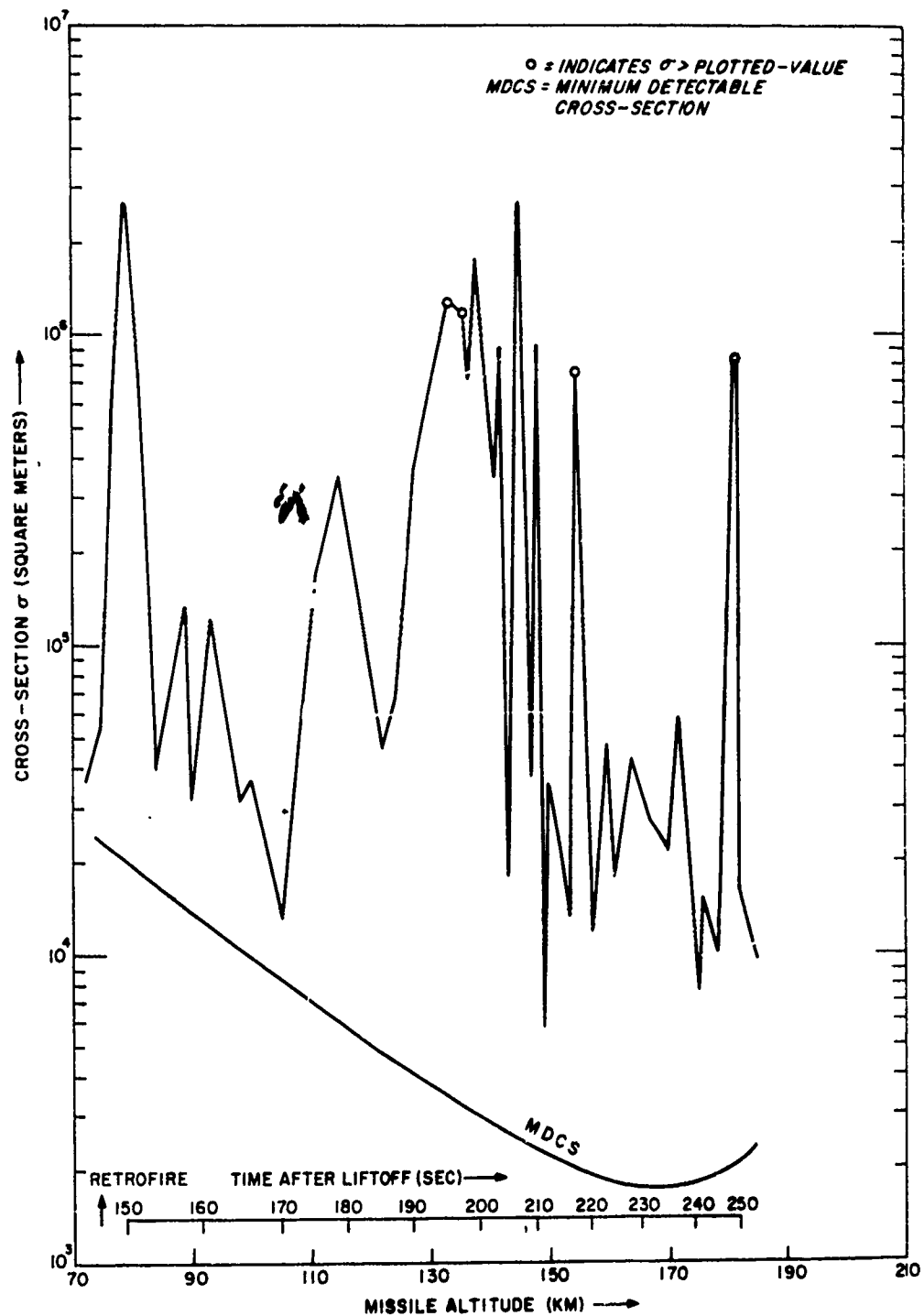


Figure 12. Signature cross section, SATURN SA-5, Brunswick, Georgia receiving San Salvador.

2-16

SECRET

SECRET

readout provides a display covering a range from 0 to 85 cycles per second (c/s). Since the pulse repetition frequency was 100 c/s, frequencies higher than 50 c/s are ambiguously folded into the 0- to 50-c/s range.

Figure 13 presents the doppler history for the signature obtained on the Brunswick-receiving-San Salvador path. By using postflight information for the S-IV trajectory and a ballistic flight approximation for the S-I trajectory, doppler frequencies were calculated for the two stages, and these frequencies are presented in Figure 14. Also plotted on Figure 14 are the observed doppler spectral "lines" shown in Figure 13.

The doppler spectral "lines" of Figure 13 are somewhat intermittent and exhibit substantial spectral spreading of the discrete-doppler lines. The target echoes produce a noise-like spectrum over practically the entire doppler-filter passband (0- to 85 c/s) during the 180- to 195-second and 215- to 240-second time periods. The retro-rocket signature is characterized by a low frequency spectrum which is spread from 9 to 10 c/s.

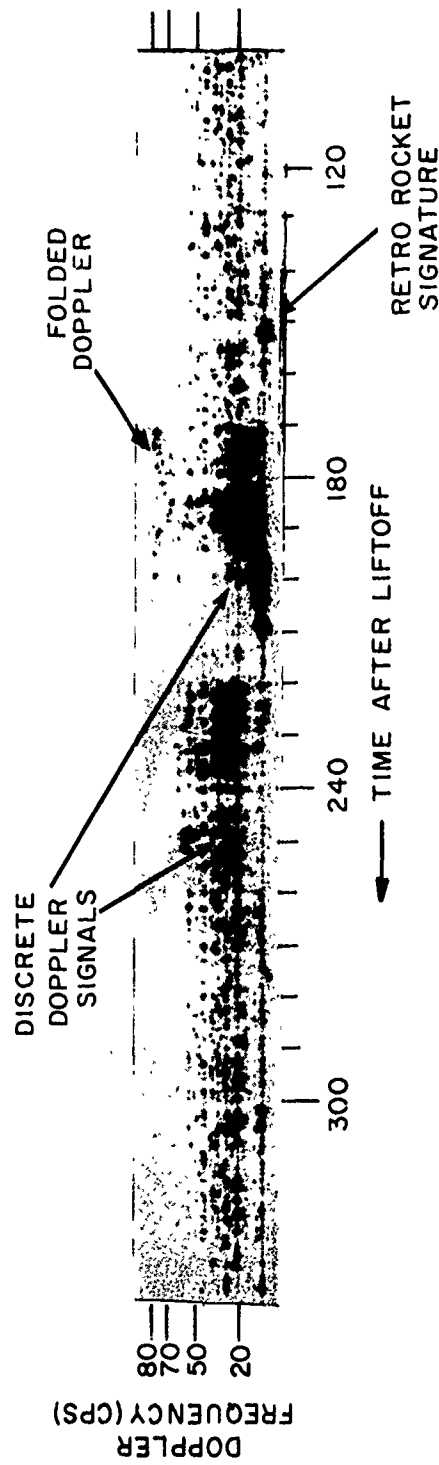
The observed and calculated doppler frequencies agree closely for the 150- to 180-second interval, but the observed doppler frequencies depart significantly from predicated doppler frequencies at the end of the "doppler noise" period ($T_0 + 195$ seconds). During the interval from $T_0 + 190$ to $T_0 + 210$ seconds, the observed change of doppler frequency does not seem to be related to the doppler frequencies calculated either for the S-I or for the S-IV stage, but later the change does approximate that predicted for the S-I stage from $T_0 + 240$ to 250 seconds, when a discrete-doppler spectral line is again obtained.

It appears, therefore, that the observed target was not simply caused by the flame of the S-IV stage, although an accurate description of the target behavior is not possible when only the Brunswick-receiving-San Salvador data are used.

2-17

SECRET

SECRET



AMR 0169
SATURN SA-5
BRUNSWICK, GA RECEIVING SAN SALVADOR ISLAND
OPERATING FREQUENCY: 22.8 MC/S
DOPPLER SPECTRUM

Figure 13. AMR test 0169, SATURN SA-5, Brunswick, Georgia receiving San Salvador, operating frequency - 22.8 Mc/s.

SECRET

SECRET

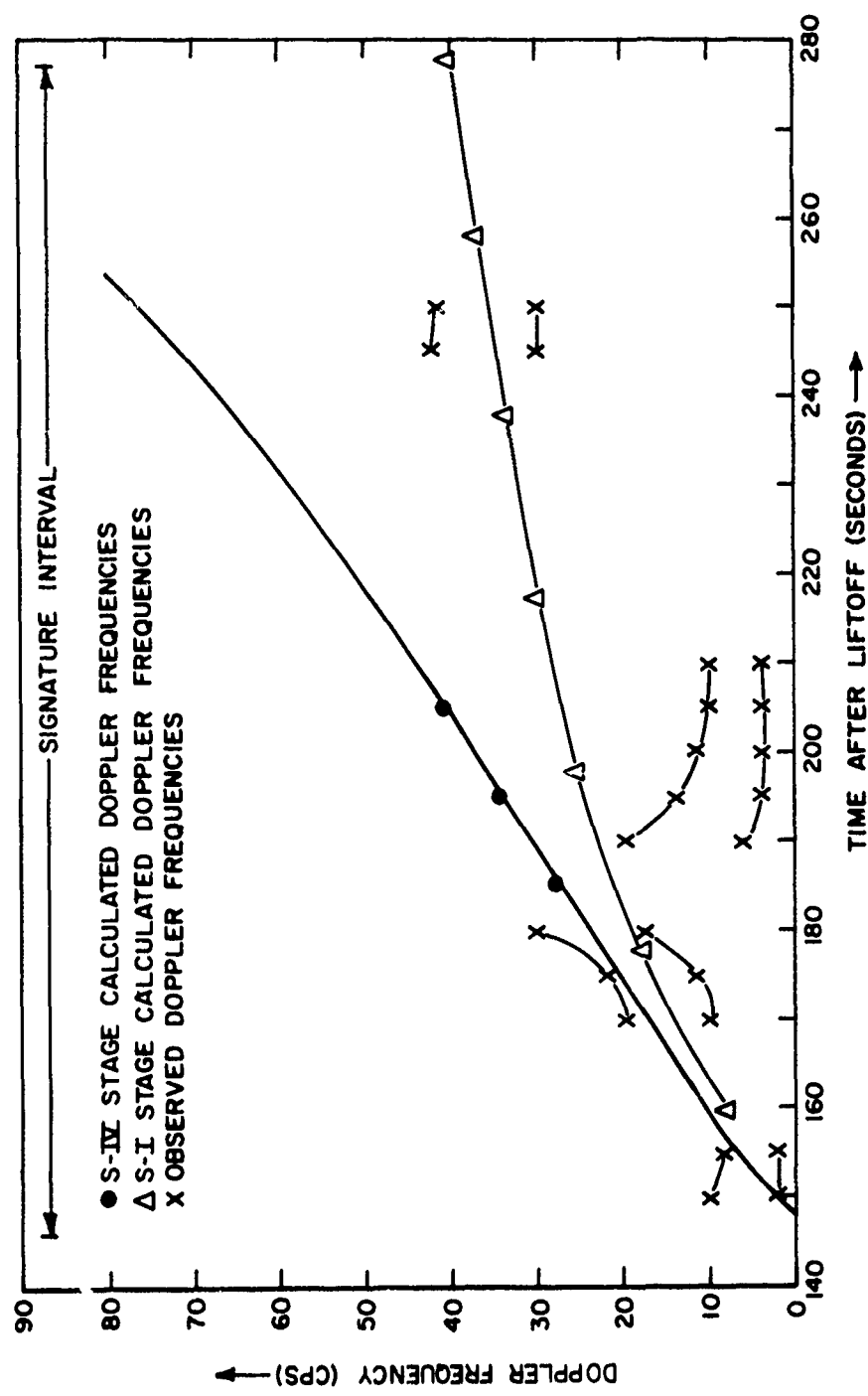


Figure 14. Comparison of calculated and observed doppler-spectrum lines, SATURN SA-5 stages S-I and S-IV, Brunswick, Georgia receiving San Salvador.

SECRET

SECRET

2.1.2.4. Cape Kennedy Receiving San Salvador

Cape Kennedy's reception of the San Salvador transmissions provides an interesting comparison with quasi-tail-on (Brunswick transmitter) versus quasi-head-on (San Salvador transmitter) illumination of the missile target as measured at Cape Kennedy. Cape Kennedy measurements of San Salvador signals for the SA-5 test produced the range versus time signature presented in Figure 15. A large target produced by the retro-rockets was observed from $T_0 + 148$ seconds to $T_0 + 155$ seconds; no further signature was obtained until $T_0 + 168$ seconds. A strong, specular signature occurred from $T_0 + 168$ seconds to $T_0 + 267$ seconds during the burning of the S-IV stage.

The signatures observed during the S-IV propulsion interval were much stronger on the paths with scatter angles greater than 90 degrees (i. e. , Cape Kennedy receiving San Salvador), as opposed to a path with scatter angles less than 90 degrees (i. e. , Cape Kennedy receiving Brunswick). Because of a calibration equipment malfunction for Cape Kennedy-receiving-San Salvador measurements, it was not possible to obtain accurate amplitude (i. e. , cross section) information for these data.

The pulse-doppler spectrum for Cape Kennedy's reception of the San Salvador transmissions is presented in Figure 16. The retro-rocket signature is observed to have a doppler spectrum of 0 to 12 c/s, with a significant decrease in background noise-doppler intensities. After the retro-rocket signature, the doppler record shows an increase in background noise doppler; at $T_0 + 165$ seconds, a signature spectrum spread of about 30 c/s is observed. At $T_0 + 245$ seconds, a spread spectrum signature is again visible. The calculated bare-body doppler frequencies, using the Cape Kennedy-to-San Salvador path for both the S-I and S-IV stages, are presented in Figure 17. The signature spectrum observed at $T_0 + 245$ seconds is of the order of the doppler expected

SECRET

SECRET

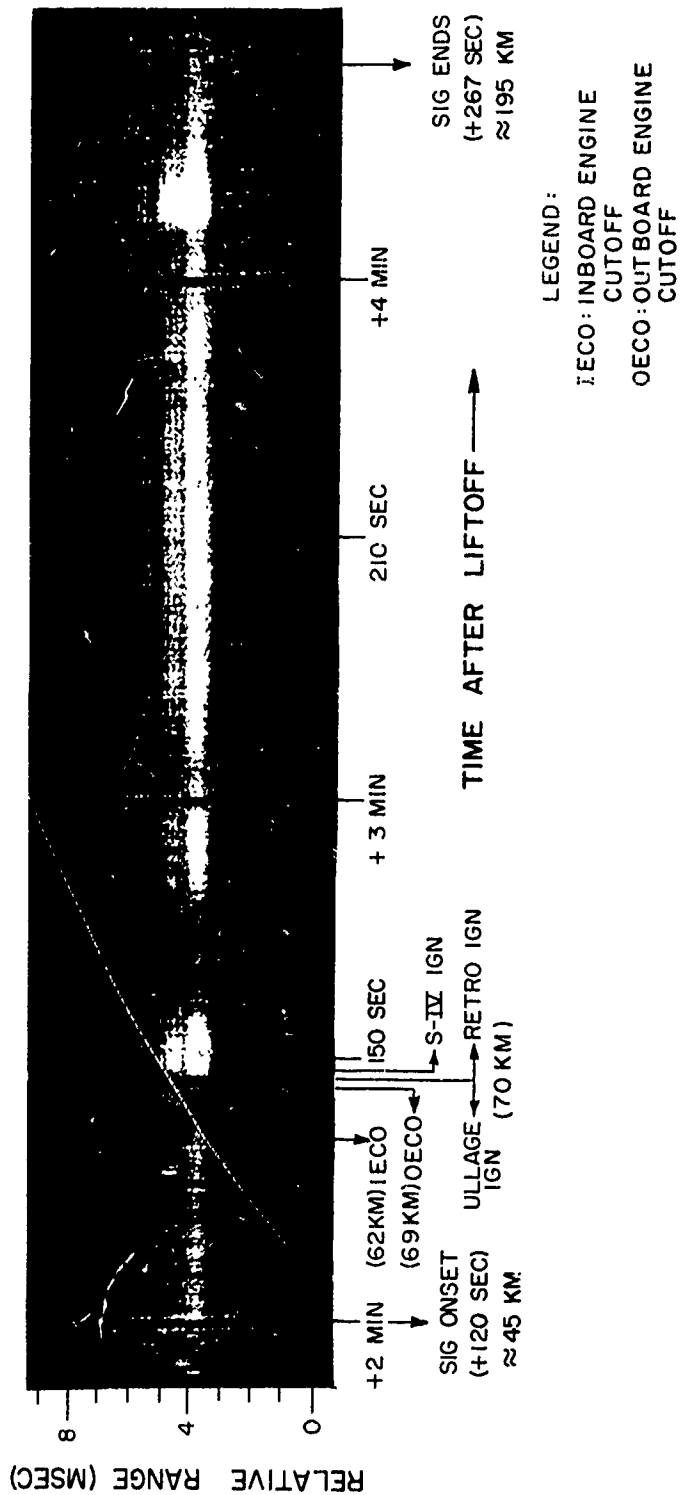
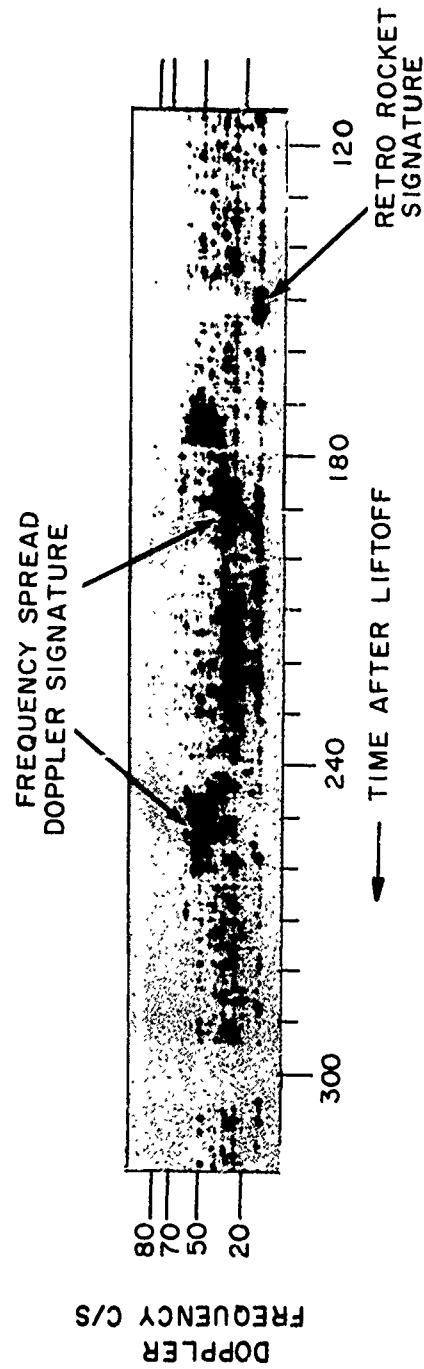


Figure 15. AMR test 0169, SATURN SA-5, Cape Kennedy receiving San Salvador, operating frequency - 22.8 Mc/s.

SECRET

SECRET



AMR TEST 0169
SATURN SA-5
CAPE KENNEDY RECEIVING SAN SALVADOR ISLAND
OPERATING FREQUENCY: 22.8 MC/S
DOPPLER SPECTRUM

Figure 16. AMR test 0169, SATURN SA-5, Cape Kennedy receiving San Salvador, operating frequency - 22.8 Mc/s.

SECRET

SECRET

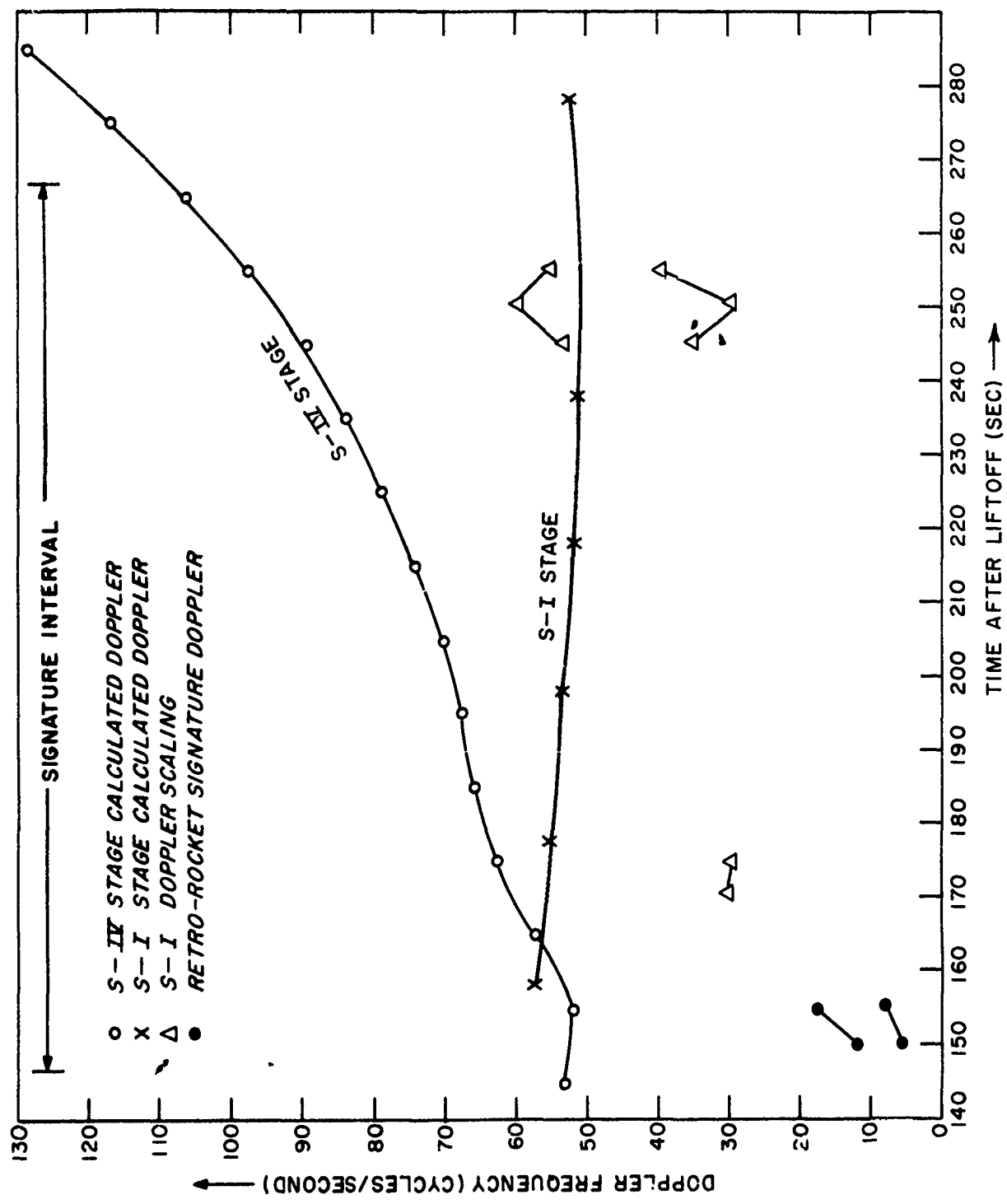


Figure 17. Comparison of calculated and observed doppler-spectrum lines. SATURN SA-5, stages S-I and S-IV, Cape Kennedy receiving San Salvador.

SECRET

SECRET

for the ballistic S-I stage. Again, no doppler signature was evident which correlated with that expected for the S-IV flame signature.

It would appear, therefore, that the enhancement of returns in the $T_0 + 240$ -second to $T_0 + 260$ -second interval may be associated with out-gassing of the S-I stage since both coherent measurements indicate a doppler spectrum appropriate to that calculated for a ballistic S-I stage trajectory.

2.1.2.5. Brunswick Monostatic

The Brunswick, Georgia monostatic radar operations produced a signature at the time of retro-rocket ignition (Figure 18). The signature appears at $T_0 + 148$ seconds and ends at $T_0 + 154$ seconds, its duration is approximately 4 seconds longer than the interval of high absorption for the VHF telemetry signals. This signature exhibits a cross section of approximately 4.8×10^6 square meters (Figure 19), which is about the same order of magnitude obtained for the San Salvador receiving Brunswick, Brunswick receiving San Salvador, and Cape Kennedy receiving San Salvador measurements. The lack of a discrete flame signature for the time history of the powered S-IV stage ($T_0 + 160$ to 240 seconds) strongly suggests that the S-IV flame target cross section was much smaller than that created by the firing of retro-rockets or by the outgassing S-I stage.

2.2. THE SA-6 FLIGHT

The SATURN SA-6 test vehicle was launched at 1707 GMT on 28 May 1964, at a 107° T azimuth from Cape Kennedy, Florida. The launch was successful, and the flight trajectory and staging times were generally similar to the SA-5 test.

2.2.1. VHF Telemetry from the SA-6 Vehicle

The amplitude of VHF telemetry signals from the SA-6 vehicle indicated attenuation phenomena similar to those of the SA-5 test. On

SECRET

SECRET

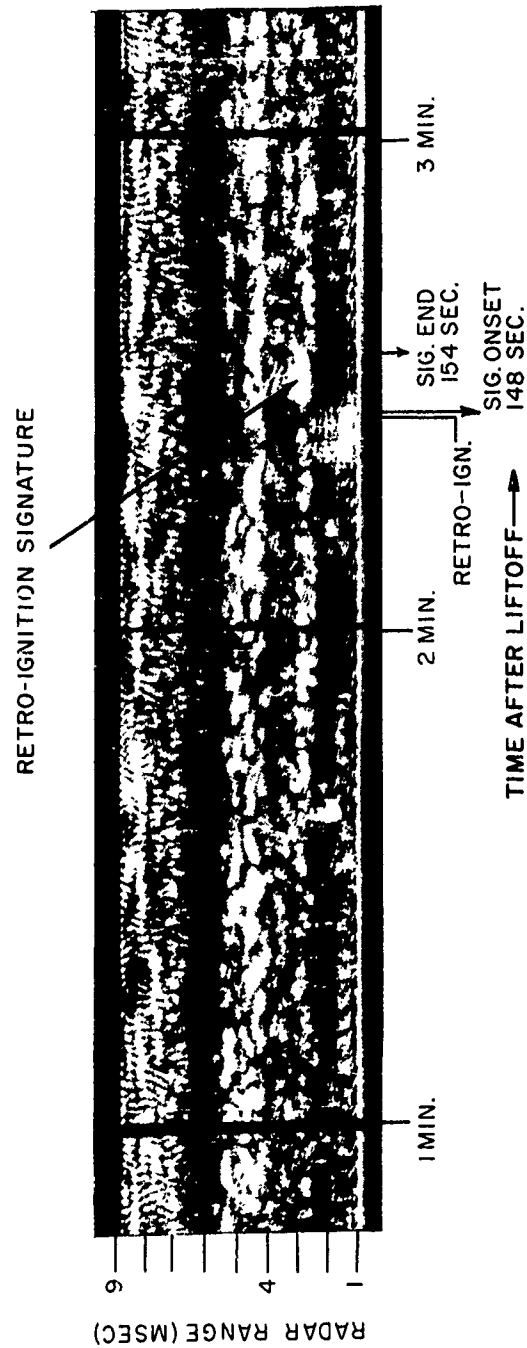


Figure 18. AMR test 0169, SATURN SA-5 signature, liftoff - 1625:01Z, Brunswick, Georgia monostatic radar, 29 January 1964.

SECRET

SECRET

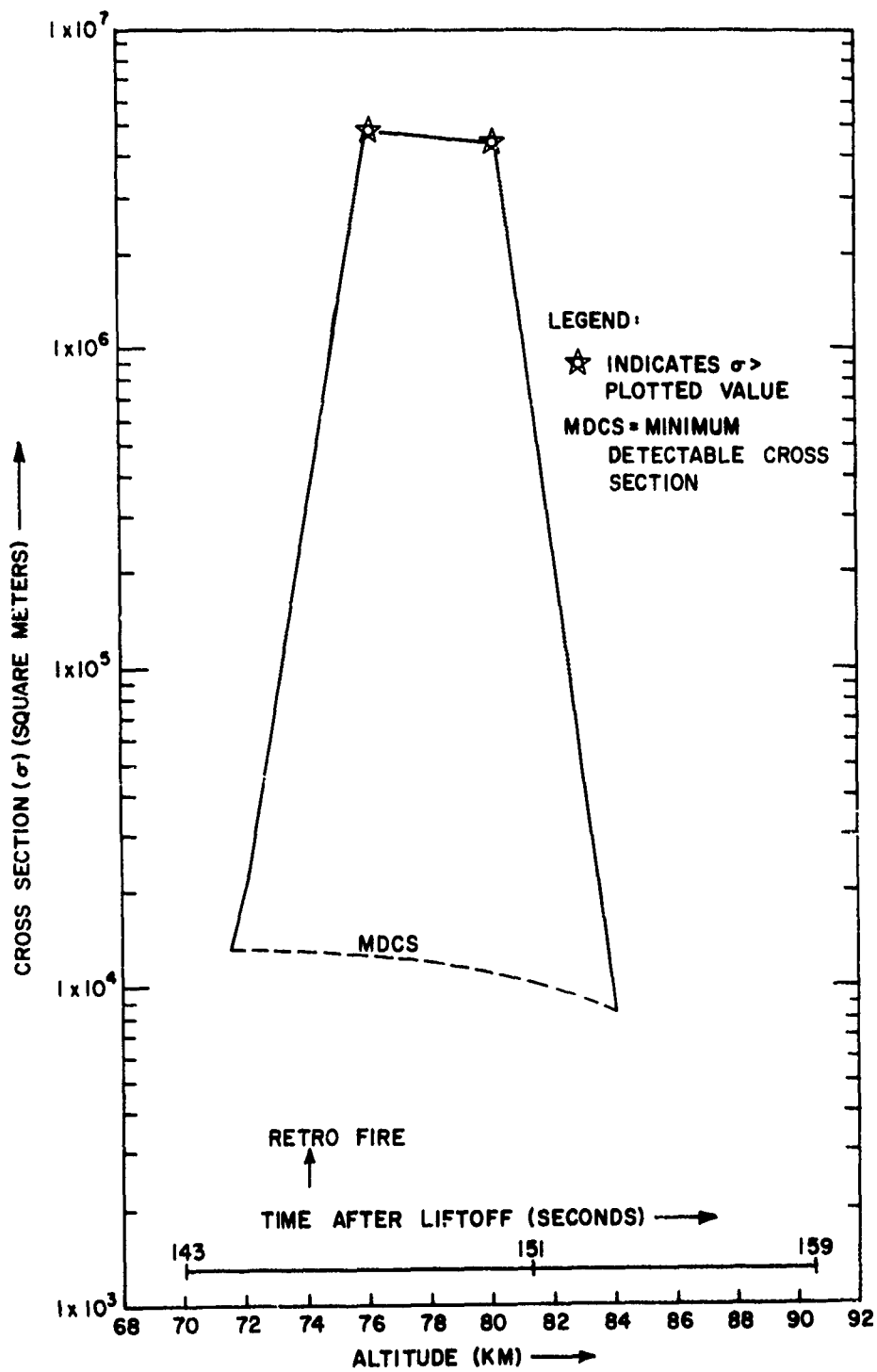


Figure 19. Cross section of the Brunswick, Georgia monostatic retro-rocket signature, SATURN SA-5.

2-26

SECRET

SECRET

most of the telemetry links, the measured attenuation was less severe than for the SA-5 test. Retro-rocket ignition again produced a sharp reduction in signal strength to receiver detection threshold at the Cape monitoring site, as indicated by Figure 20. (SA-6 telemetry was producing relatively low signal levels prior to the time of retro-rocket ignition, thus, the measured attenuation appears to be smaller than for SA-5.) The onset of absorption at retro-rocket ignition was more gradual, and recovery was slower for the SA-6 test than for the SA-5 test. Recovery of the Cape Kennedy-telemetry-link signals to pre-retro-ignition levels took from 4 to 6 seconds, as may be noted in Figure 20.

2.2.2. Signatures Observed with HF Polystatic Direct-Look Radars

The signatures of the SA-6 tests, as observed by HF operations, were badly obscured by radio interference on the Cape Kennedy-receiving-Brunswick path and by direct coupling signals on the San Salvador-receiving-Brunswick path, as well as its reciprocal path direction. Nevertheless, the signature features observed were remarkably similar to those for the SA-5 test.

The Cape Kennedy-receiving-San Salvador signature for the SA-6 test is shown in Figure 21. After the retro-rockets ignited, a strong and discrete signature was observed from $T_0 + 150$ seconds to $T_0 + 156$ seconds, after which the amplitude of returns significantly decreased. The duration of these strong returns is the same as the time interval of measured VHF telemetry attenuation for the instrument unit (IU) transmissions (Figure 20). At $T_0 + 175$ seconds, when the missile reaches 97 km altitude, the amplitude of discrete HF target echoes again increases, and the signature remains visible until $T_0 + 378$ seconds (not shown in Figure 21).

SECRET

SECRET

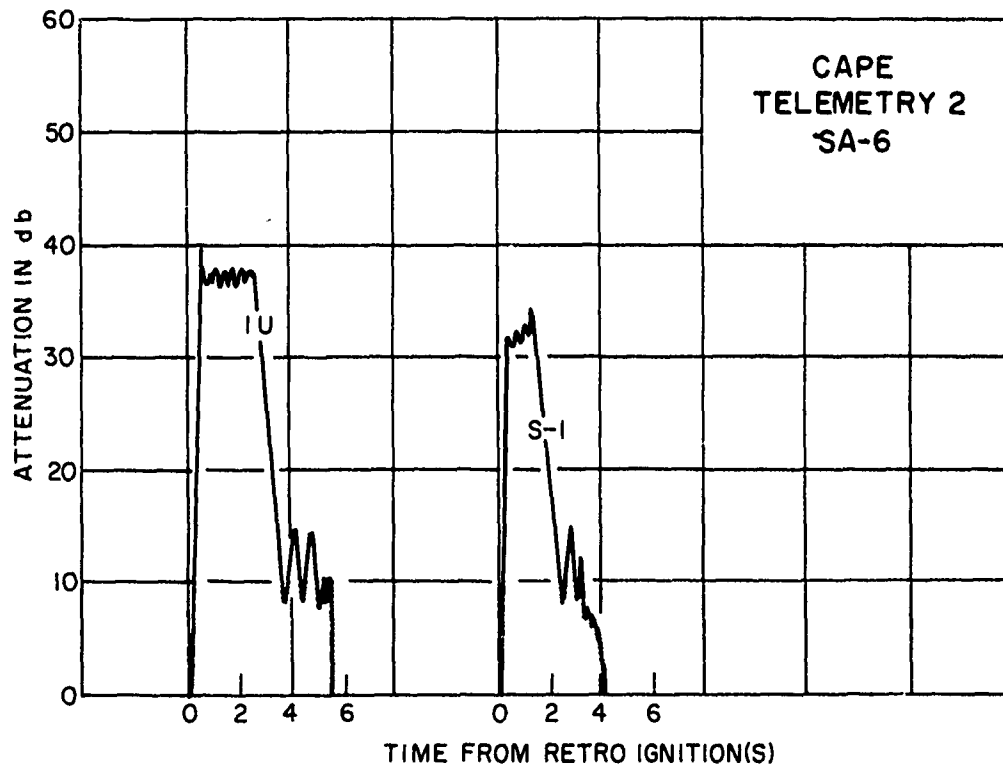
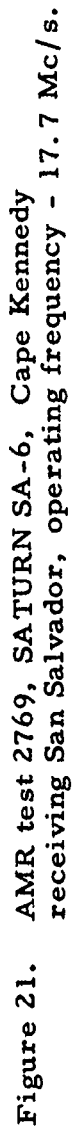


Figure 20. Telemetry signal attenuation due to retro-rockets.

2-28

SECRET

SECRET



SECRET

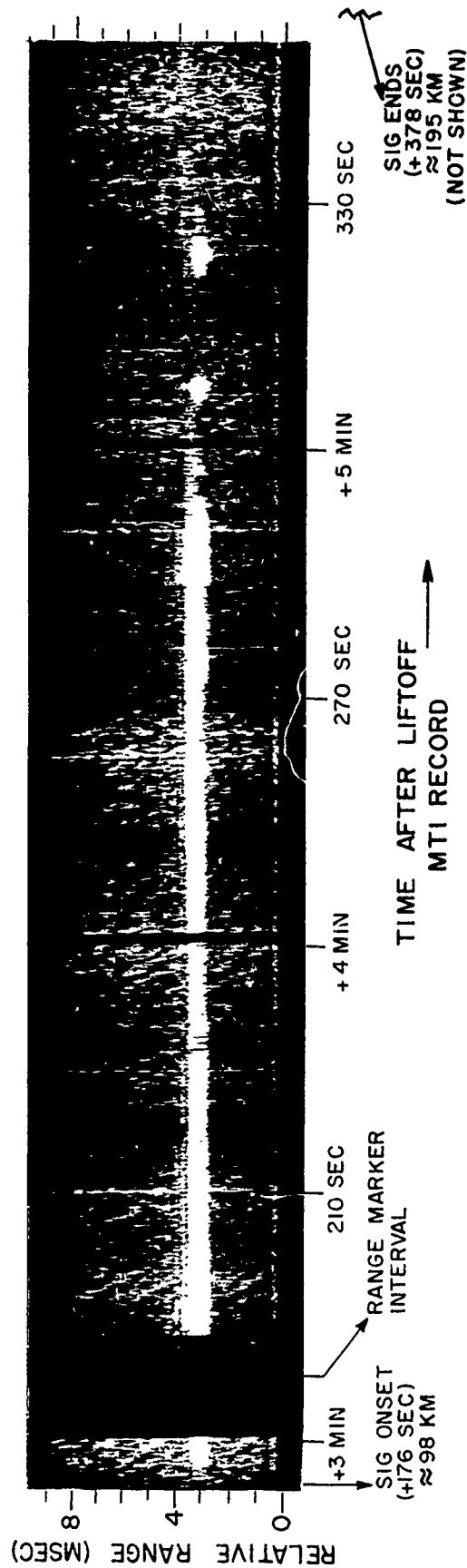
The signature in the interval from $T_0 + 175$ seconds to $T_0 + 364$ seconds again appears to be the result of out-gassing from the S-I stage. The powered S-IV stage signature is shown more clearly in Figure 22 (the result of MTI processing of the signals shown in Figure 21).

At $T_0 + 294$ seconds, the discrete echoes are observed to occur at two slightly separated ranges, and continue to form two distinct signatures through $T_0 + 330$ seconds. To substantiate that these two signatures were from the S-I and S-IV stages, a calculation was made of relative range separation for the two stages on the Cape Kennedy-receiving-San Salvador path, assuming a ballistic projectile trajectory for the S-I stage. Although the S-I stage did not follow a truly ballistic course after main engine cutoff, because of out-gassing effects and previous retro-rocket deceleration, this assumption should provide a rough first approximation to the relative positions of the two separate targets in the absence of post-burn S-I trajectory data. The result of this calculation yields a path-range separation of 80 km, or approximately 0.27 millisecond (time delay), for these targets at $T_0 + 320$ seconds. This difference in path-range is consistent with the observed target returns (Figure 22) which show a path range difference of approximately 0.3 millisecond.

The pulse-doppler spectrum of SA-6 for the Cape Kennedy-receiving-San Salvador signature is presented in Figure 23. There are, clearly, two doppler signatures observed beginning at $T_0 + 195$ seconds when a low frequency-doppler line appears below the previous discrete doppler returns at 30 to 40 c/s. The doppler signature first appears at

SECRET

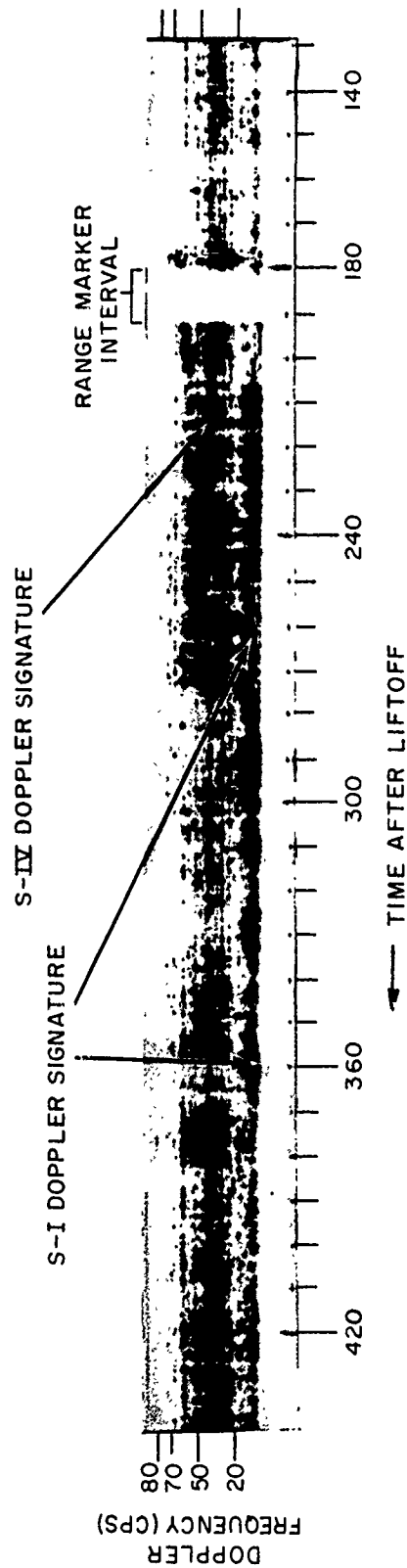
SECRET



SECRET

Figure 22. AMR test 2769, SATURN SA-6, MTI record, Cape Kennedy receiving San Salvador, operating frequency - 17.7 Mc/s.

SECRET



AMR TEST 2769

SATURN SA-6

CAPE KENNEDY RECEIVING SAN SALVADOR

OPERATING FREQUENCY: 17.7 MC/S

DOPPLER SPECTRUM

Figure 23. AMR test 2769, SATURN SA-6, doppler spectrum, Cape Kennedy receiving San Salvador, operating frequency - 17.7 Mc/s.

SECRET

SECRET

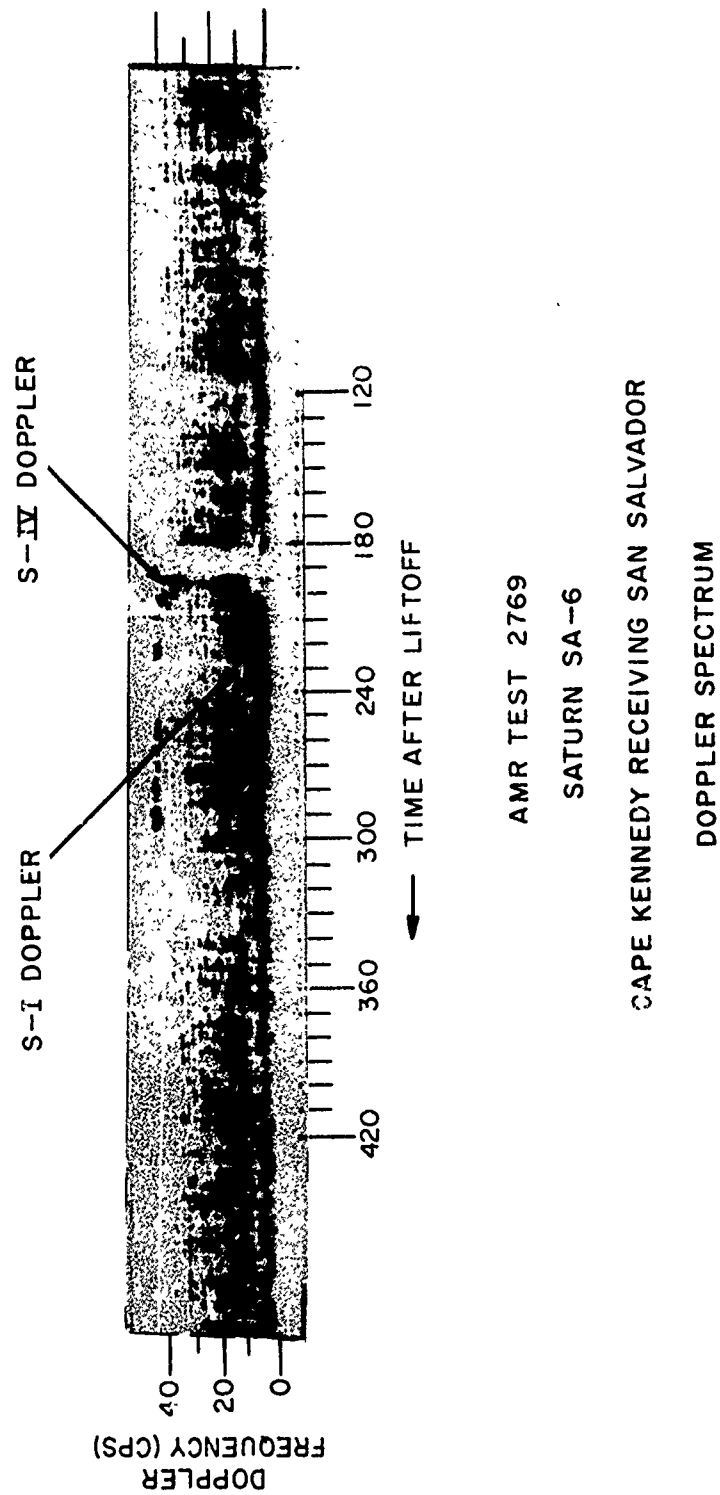
$T_0 + 175$ seconds, however, a set of range markers was applied to the record at $T_0 + 181$ seconds, which created a 10-second break in the data. The decreasing doppler-frequency component which separates from the increasing doppler-signature component is shown more clearly in Figure 24; this figure presents an expanded display of the 0- to 42-c/s spectrum. The retro-rocket signature is observed to produce a low-frequency doppler spectrum similar to that observed for the SA-5 test (Figure 23). Figure 25 presents a comparison of the calculated and observed doppler frequencies for the S-I and S-IV stages. A rather good agreement exists between the observed doppler trends and the calculated values for the two stages, even though the observed dopplers exhibit a significant amount of "spectral spreading". These data, thus, substantiate the hypothesis that echoes from the two stages could account for the complex signature characteristics observed during this test.

Since the Cape Kennedy-receiving-San Salvador signature character was complex (and derives from several distinctly different and inter-mixed target responses), no single or simple cross section calculation can describe this signature quantitatively.

The strong E_s -coupling signals, previously described for the Brunswick and San Salvador operations, make it impossible to distinguish the missile signatures from the interference; accordingly, records are not presented.

SECRET

SECRET



SECRET

Figure 2 AMR test 2769, SATURN SA-6, doppler spectrum (continued), Cape Kennedy receiving San Salvador.

SECRET

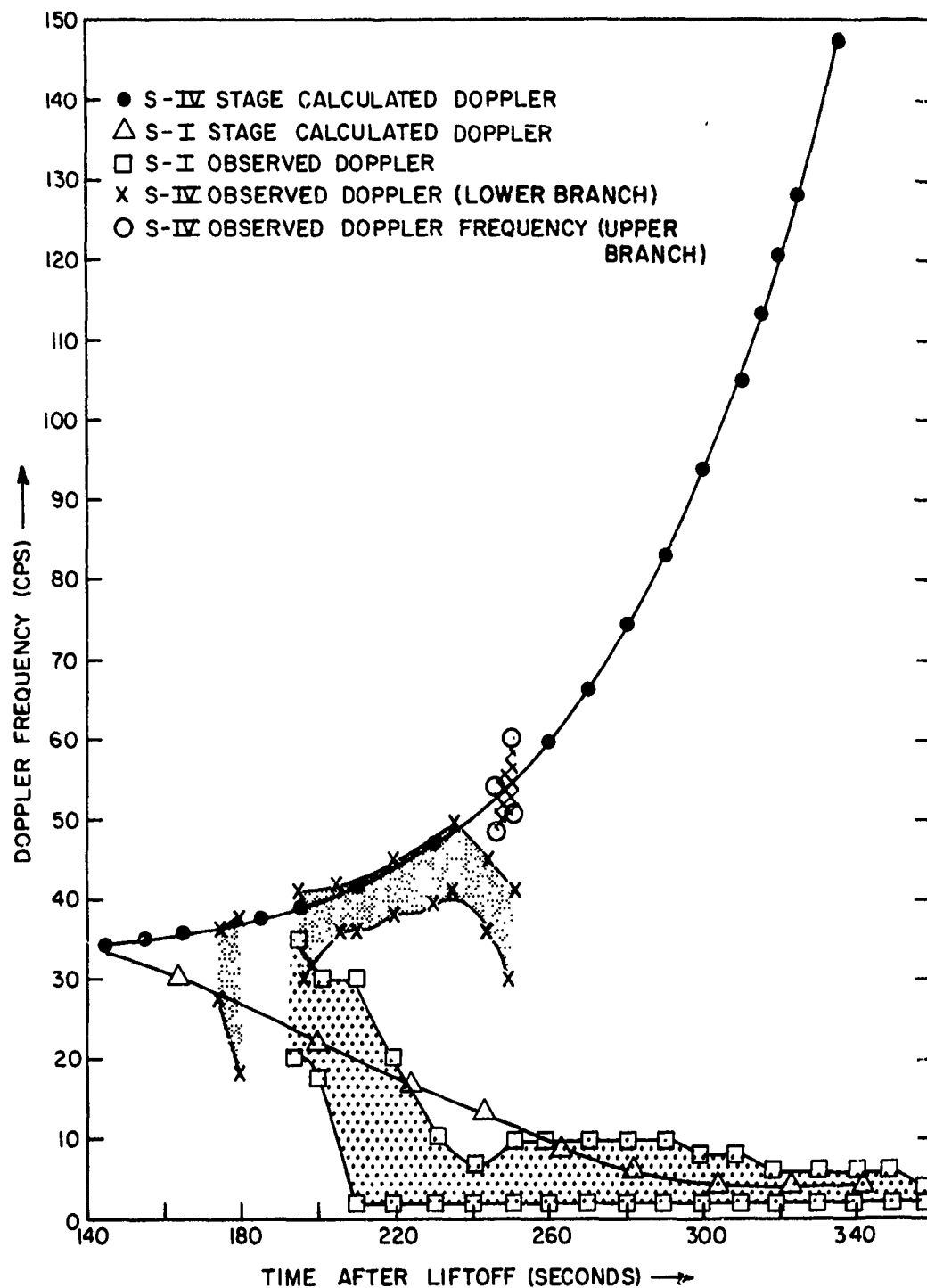


Figure 25. Comparison of calculated and observed doppler spectrum, SATURN SA-6, stages S-I and S-IV, Cape Kennedy receiving San Salvador.

2-35

SECRET

SECRET

3. FLAME-ASSOCIATED VHF AND HF PHENOMENA

The modulation of the VHF telemetry signals by the rocket flame has been observed to produce both rapid and large amplitude scintillations, as well as a noisy spectral spreading of the monitored VHF telemetry data (Ref. 3). The maximum frequency spread, as reported by Ely and Hockenberger (Ref. 3, Figures 21 and 22), was approximately 1000 c/s from the carrier frequency for both liquid- and solid-fueled rocket motors. The noise modulation of the VHF telemetry is most pronounced when the vehicle is in the 30-km to 200-km altitude region. The noise modulation is reported most severe for the Cape Kennedy monitoring sites at tail-on aspects, and this modulation becomes gradually less for side and head-on viewing aspects which do not pass through the rocket flame.

On the basis of observed VHF telemetry flame effects, one might expect similar amplitude and spectral modulation of the energy reflected, at HF frequencies, from the ionized rocket plume at similar aspect angles. For HF pulse radar observations of rocket launches, rapid amplitude fluctuations would predominate, and discrete flame signatures would appear quite "noisy" even when the received signal is well above normal background noise. This has been true for flame signatures observed in the past by the Electro-Physics Laboratories, and statistical studies of these amplitude fluctuations have been made previously (Ref. 7). The pulse-doppler measurements presented in this report indicate substantial "spectrum spreading" for the particular targets observed. Although the complex target returns observed for the SA-5 and SA-6 tests would be expected to produce a number of discrete spectral lines, the "doppler spreading" of discrete signatures (e.g., the S-IV doppler "line" shown in Figure 23) would seem to be associated with flame-induced modulation effects similar to those observed on VHF telemetry transmissions (Ref. 8). Asymmetric "frequency spreading" of missile flame signatures has been observed

SECRET

SECRET

by most HF CW-doppler radar operations (Refs. 9 and 10) for targets above 100-km altitude, and the presence of both amplitude and phase-flame "noise" modulations appears to constitute a mechanism for generating this "spectrum spreading".

3-2

SECRET

SECRET

4. CONCLUSIONS

The following conclusions are derived from the rocket launches described.

- (1) HF radar observations of the SA-5 and SA-6 vehicles produced target signatures of considerable complexity. Some features of these signatures would appear valuable in applications to over-the-horizon radars, while others would, if not recognized, provide serious degradation to system performance for some radar formats. A number of the particular signature characteristics should be recalled, and conclusions should be drawn as to their significance.
- (2) First, the dual-ranged echo traces observed, one from the true second-stage flame-target and another from the coasting (and outgassing) discarded first stage were resolved by the experimental radars when the first-stage outgassing signature no longer obscured the more desirable flame target. It is clear, however, that the first-stage signature, although it might characterize an interesting event in the launch sequence, its range-rate and derived doppler velocity read-out would provide a false indication of the desired target motion for a substantial interval of the signature.
- (3) The very small solid propellant retro-rockets of the SATURN S-1 stage produce a surprisingly large HF target response. The retro-fire signature, at about 70 km altitude was clearly 2 to 3 orders of magnitude larger than the high-thrust-level flame echoes observed at this and somewhat higher altitudes. Simultaneous VHF telemetry blackout and SHF radar signal degradation were observed, along with the brief, but large, HF radar echo enhancement caused by the retro-fire event. This indicates that unusually large electron

4-1

SECRET

SECRET

densities or density gradients were present at this time. The retro-fire signature, therefore, denotes an event of some interest in the overall sequence of launch phenomena, but despite the large cross section of such a target, its short persistence, spectral dispersion, and non-correlated amplitude variations would prove of little value for discerning the proper target motion and trajectory.

(4) The observed doppler-frequency spreading and rapid amplitude scintillation for HF radar signals reflected from the powered targets, for both the transient and more persistent signature features, closely resemble the noise-like phase and amplitude modulations appearing on VHF telemetry signals transmitted through the exhaust regions. These flame and ambient plasma effects would seriously degrade the resolution of discrete target motion by the use of a pulse-doppler radar format. In particular, a pulse-doppler, over-the-horizon radar system which must use a low pulse repetition frequency (PRF) (to achieve a sufficiently large, unambiguous range) would perform poorly against these target characteristics because the PRF would be a small fraction of either the target-motion doppler or the plasma-dispersed spectrum, or both.

SECRET

SECRET

5. REFERENCES

1. Taylor, J. E., et al., "Polystatic Radar Equipment," (U), Internal Technical Memorandum No. 141, Electro-Physics Laboratories, Hyattsville, Maryland, 23 October 1963, (Unclassified).
2. EPL Staff, "Considerations of Certain Close-In Observations of Ballistic Missile Launches," (S), Proposal No. 39063-215, Electro-Physics Laboratories, Hyattsville, Maryland, 26 August 1963, (Secret).
3. Ely, Olen P., and Hockenberger, Robert W., "Rocket Exhaust Effects on Radio Frequency Transmission," (U), AIAA 6th Solid Propellant Rocket Conference, Washington, D. C., 1 February 1965.
4. Ely, Olen P., Hockenberger, Robert W., Howell, Parley and Boone, Geddes, "Radio Frequency Evaluation of SA-5 Vehicle," (U), Technical Memorandum X-53073, NASA, George C. Marshall Space Flight Center, Huntsville, Alabama, 10 June 1964.
5. Ely, Olen P., Hockenberger, Robert W., Howell, Parley, and Boone, Geddes, "Radio Frequency Evaluation of SA-6 Vehicle," (U), Technical Memorandum X-53170, NASA, George C. Marshall Space Flight Center, Huntsville, Alabama, 24 November 1964.
6. Bowser, C. A., and McCall, D. R., "The Determination of Radar Cross Sections for Polystatic Observations," (U), External Technical Memorandum No. 50, Electro-Physics Laboratories, Hyattsville, Maryland, January 1966, (Secret).
7. Kelso, J. M., "Some Statistical Properties of Discrete Missile Signatures," (S), CHAPEL BELL Report No. 48, Electro-Physics Laboratories, Hyattsville, Maryland, 6 July 1964, (Secret).
8. Geiger, A. A., "Analysis of the Effects of Rocket Exhaust Fluctuations on FSK Telemetry," AIAA 6th Solid Propellant Rocket Conference, 1 February 1965, Washington, D. C., (Unclassified).
9. Curley, S., "AMR Polystatic Phenomenology Data," Correspondence to Office of Naval Research (RD-153541), (S), Air Force Cambridge Research Laboratories Office of Aerospace Research, 24 June 1965, (Secret).

SECRET

SECRET

5. REFERENCES (continued)

10. Barry, G. , "Doppler Shifted HF Echoes Observed During Rocket Launching," (S), Technical Report No. 51, Stanford Research Institute, October, 1962, (Secret).

SECRET

~~SECRET~~

Security Classification

DOCUMENT CONTROL DATA - R&D		
(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)		
1. ORIGINATING ACTIVITY (Corporate author)		2a. REPORT SECURITY CLASSIFICATION
ITT Electro-Physics Laboratories, Inc.		SECRET
Hyattsville, Maryland		7b. GROUP
		GP-3
3. REPORT TITLE		
RADAR AND TELEMETRY OBSERVATIONS FOR TWO SATURN LAUNCH VEHICLES (U)		
4. DESCRIPTIVE NOTES (Type of report and inclusive dates)		
Report No. 65 of the Chapel Bell Series		
5. AUTHOR(S) (Last name, first name, initial)		
Bowser, Carl A.		
6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
January 1966	64	10
8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)	
4204(00)	Chapel Bell Report No. 65	
b. PROJECT NO.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	
NR 088-024	NA	
c.		
d.		
10. AVAILABILITY/LIMITATION NOTICES		
All distribution of this report is controlled. Qualified DDC users shall request through the Office of Naval Research, Code 418.		
11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY	
NA	Code 418 Office of Naval Research Washington 25, D. C.	
13. ABSTRACT		
<p style="text-align: center;"><u>SECRET</u></p> <p>Recently released information concerning rocket-exhaust effects upon VHF telemetry transmissions for several launches of SATURN space vehicles has been compared with data obtained for line-of-sight HF radar observations of these launches. A correspondence of certain VHF attenuation events with HF radar echoes is noted, and some inferences connected with the behavior of r-f transmissions in the presence of flames for missiles using liquid and solid fuels, respectively, are presented.</p> <p>A correlation is made of the complex target echoes obtained on HF POLYSTATIC radars with performance of the S-I and S-IV stages of the SATURN vehicles. Variations of radar cross section for the HF targets are also presented.</p> <p>The information reported herein is intended to furnish data and analysis thereof for powered missile target and signature characteristics, which should be of significance to the proper design and operation of over-the-horizon radar detection (OHD) systems.</p> <p style="text-align: center;"><u>SECRET</u></p>		

DD FORM 1473
1 JAN 64

~~SECRET~~

Security Classification

SECRET

Security Classification

14	KEY WORDS	LINK A		LINK B		LINK C	
		ROLE	WT	ROLE	WT	ROLE	WT
Saturn Vehicle Characteristics at High Frequencies							
Saturn Results During the Polystatic Experiments							

INSTRUCTIONS

1. **ORIGINATING ACTIVITY:** Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization (*corporate author*) issuing the report.

2a. **REPORT SECURITY CLASSIFICATION:** Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2b. **GROUP:** Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. **REPORT TITLE:** Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. **DESCRIPTIVE NOTES:** If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. **AUTHOR(S):** Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. **REPORT DATE:** Enter the date of the report as day, month, year, or month, year. If more than one date appears on the report, use date of publication.

7a. **TOTAL NUMBER OF PAGES:** The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7b. **NUMBER OF REFERENCES:** Enter the total number of references cited in the report.

8a. **CONTRACT OR GRANT NUMBER:** If appropriate, enter the applicable number of the contract or grant under which the report was written.

8b, 8c, & 8d. **PROJECT NUMBER:** Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9a. **ORIGINATOR'S REPORT NUMBER(S):** Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9b. **OTHER REPORT NUMBER(S):** If the report has been assigned any other report numbers (*either by the originator or by the sponsor*), also enter this number(s).

10. **AVAILABILITY/LIMITATION NOTICES:** Enter any limitations on further dissemination of the report, other than those

imposed by security classification, using standard statements such as:

- (1) "Qualified requesters may obtain copies of this report from DDC."
- (2) "Foreign announcement and dissemination of this report by DDC is not authorized."
- (3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through _____."
- (4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through _____."
- (5) "All distribution of this report is controlled. Qualified DDC users shall request through the Office of Naval Research, Code 418."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. **SUPPLEMENTARY NOTES:** Use for additional explanatory notes.

12. **SPONSORING MILITARY ACTIVITY:** Enter the name of the departmental project office or laboratory sponsoring (*paying for*) the research and development. Include address.

13. **ABSTRACT:** Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as (TS), (S), (C), or (U).

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. **KEY WORDS:** Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, rules, and weights is optional.

(THIS PAGE IS UNCLASSIFIED)

SECRET

Security Classification



DEPARTMENT OF THE NAVY
OFFICE OF NAVAL RESEARCH
875 NORTH RANDOLPH STREET
SUITE 1425
ARLINGTON, VA 22203-1995

IN REPLY REFER TO:

5513
Ser 43/058

AUG 30 2010

From: Chief of Naval Research
To: Defense Technical Information Center, 8725 John J.
Kingman Road, Suite 0944, Ft. Belvoir, VA 22206-6218

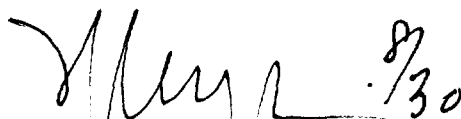
Subj: FREEDOM OF INFORMATION ACT (FOIA) REQUEST

Ref: (a) SECNAVINST M-5510.36
(b) DTIC FOIA ltr of 26 Jun 09

Encl: (1) Radar Telemetry Observations for Two Saturn
Launch Vehicles (U)

1. In accordance with reference (a), a declassification review per reference (b), has been conducted on enclosure (1). This document is hereby downgraded from CONFIDENTIAL to UNCLASSIFIED and is approved for public release with unlimited distribution.

2. You may contact Mr. Derrick Shack (ONR 43) at 703-696-1499 or by email at derrick.shack@navy.mil for any questions regarding this matter.


NEVIN P. CARR, JR.
Rear Admiral, U.S. Navy

COPY